Kiggavik Project

Environmental Effects Assessment

Tier 2 Volume 6

Terrestrial Environment

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Kiggavik Project

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EXECUTIVE SUMMARY FOR VOLUME 6

As per the guidelines issued by the Nunavut Impact Review Board, AREVA Resources Canada Ltd. (AREVA) has prepared this Environmental Impact Statement (EIS) to assess the potential environmental effects of the Kiggavik Project (the Project) on the terrestrial environment. This volume focuses on Project environmental effects on terrain, soils, vegetation, and wildlife and wildlife habitat.

The primary Project components considered in the terrestrial assessment include all land-based construction, operation, final closure and post closure infrastructure and activities. Three access road options are considered in the assessment, including a north winter road, south winter road, and a north all-season road. Four siting options for the Baker Lake dock and storage facility are also included in the assessment.

Scope of the Assessment for the Terrestrial Environment

Terrain, soils, vegetation, and wildlife (i.e., ungulates, migratory birds, raptors, and species at risk) are selected as valued environmental components (VECs) for the terrestrial assessment because they have the potential to be affected by Project activities and are of cultural and ecological importance in the Kivalliq region.

For wildlife, key indicators are used to focus the assessment on key species or species groups that represent components of the broader resource. Wildlife species selected as indicators are:

- ungulates – caribou (*Rangifer tarandus*) and muskox (*Ovibos moschatus*)
- migratory birds – lapland longspur (*Calcarius lapponicus*) and long-tailed duck (*Clangula hyemalis*)
- raptors – peregrine falcon (*Falco peregrinus*)
- species at risk – short-eared owl (*Asio flammeus*), grizzly bear (*Ursus arctos horribilis)*, and wolverine (*Gulo gulo*)

No key indicators are used for assessing Project effects on terrain, soils and vegetation.

The NIRB developed the scope of assessment for the Project based on input from Inuit, government, and other interested stakeholders. Terrestrial-related issues incorporate results from this consultation as well as engagement activities undertaken by AREVA, which also are incorporated into the assessment.

Regulatory considerations pertaining to the terrestrial assessment include the *Nunavut Land Claims Agreement Act*, Keewatin Regional Land Use Plan, *Nunavut Wildlife Act*, *Species at Risk Act* (SARA), *Migratory Birds Convention Act*, and the Federal Policy on Wetland Conservation.

The terrestrial environment assessment is spatially bound by three assessment areas: the Project footprint, the local assessment area (LAA), and the regional assessment area (RAA). The Project footprint is the area of direct physical disturbance by the Project. The LAA is the maximum area within which Project effects can be predicted or measured with reasonable accuracy and confidence. The LAA consists of two different areas, the mine LAA and the road LAAs. The mine LAA includes a 5 km buffer that encompasses the proposed facilities and the access road between the mine sites. The LAAs for three different road options are represented by a 5 km wide buffer centered over the proposed road alignments. The RAA is a broader area within which cumulative effects may potentially occur, or a VEC is broader ranging. The dock facility options are included within the North All-Season Road and South Winter Road LAA boundaries. The RAA includes all of Judge Sissons Lake and the southern portion of Aberdeen and Schultz lakes. It encompasses a minimum buffer of 22 km around the Project footprint.

The temporal boundaries for the terrestrial assessments are generally based on the timing and duration of effects over all phases of the Project (construction, operation, final closure and post-closure). The total life of the Project is expected to be 25 years (2017 to 2042), with post-closure extending beyond the final closure phase.

A residual environmental effect caused by the Project is considered significant if it adversely affects the long-term viability of the VEC. The significance of a residual environmental effects is determined based on thresholds or standards identified for each VEC. In the absence of known thresholds or standards, professional judgment is used to determine significance. A residual effect is considered to be not significant if the effect causes a change in the VEC that is within the range of natural variability, or does not affect the integrity of the VEC in a measurable or meaningful way.

Scope of the Assessment for Terrain

Based on input from Inuit communities, government and other interested stakeholders, the Nunavut Impact Review Board guidelines requires an assessment of the potential environmental effects of Project components and activities on the terrestrial environment, including terrain and landforms. Although there are no federal and territorial guidelines, regulations standards and/or thresholds that are applicable to assess the effects of changes in terrain, a qualitative and quantitative approach is adopted for this assessment based on the previous experiences with similar projects in Nunavut and other parts of the Canadian Arctic, and professional judgment.

Issues related to Project effects on terrain identified through the public consultation and community engagement activities included potential changes in permafrost conditions, terrain stability and landforms. Key concerns focused primarily on potential melting of permafrost due to uranium and Project-related mining activities, and the cultural importance and use of landforms

Terrain is considered as a VEC for the assessment because it has the potential to be affected by Project activities through changes in permafrost conditions, terrain stability and changes in landforms, and has direct and indirect linkages with other VECs.

The terrain assessment focuses on 1) changes in permafrost conditions and terrain stability due to vegetation clearing, changes in terrain slope, redirection of surface drainage patterns, 2) changes in sub-surface water flow, excavation and blasting and 3) changes in landforms due to disturbance of eskers and other significant and sensitive landforms

Because climate change has the potential to change permafrost conditions, terrain stability, and landforms, effects of climate change is taken into account in this assessment.

Thresholds are defined using the proportion of lost terrain surface or landform relative to the total area of the mine LAA and selected based on the general knowledge of the Arctic terrestrial environment, professional judgment and the thresholds chosen for similar projects in Nunavut. A residual environmental effect caused by the Project is considered to be significant if the Project disturbance exceeds the threshold values of 30% loss of the terrain surface, 30% loss of common depositional landforms, 15% loss of permafrost sensitive landforms and 15% loss of uncommon landforms.

Existing Environment – Terrain

Surficial deposits consist mainly of glacial till and small local deltaic deposits in the RAA. Periglacial geomorphic processes in the RAA are associated with the ground that is permanently affected by the cold climate, consisting of an active layer (also known as thaw depth), excess ground-ice and a layer of perennially frozen ground. Periglacial processes observed within the mine LAA and RAA include frost wedging and frost shattering, thaw subsidence and solifluction, which shaped various landforms.

A typical top layer of surficial material profile in the mine LAA consists of a thin organic soil layer underlain by glacial till varying in thickness from less than one meter on ridges to several meters in depressions, overlying moderately jointed bedrock with good rock quality. The surficial materials have been historically grouped into six major deposits: glacial till or morainal, glaciofluvial; glaciolacustrine, glaciomarine deposits, organic, and bedrock.

Major landforms are subdivided into four different types: common depositional, glacial, permafrost sensitive and uncommon landforms. Common landforms are further subdivided into six types within the mine LAA: undifferentiated alluvial, glaciofluvial, glacial till or morainal, glaciomarine, organic and bedrock landforms. The most common landform within the mine LAA is morainal. Alluvial, glaciofluvial, morainal (glacial till), glaciomarine and bedrock landforms cover approximately 10.5% (3,786 ha), less than 1% (200 ha), 84% (30,356), 0.3% (108 ha), and 5% (1,790 ha) of the mine LAA, respectively. Glacial landforms are dominated by hummocky, bouldery glacial till and scattered boulder till moraines with frequent bedrock outcrops and shattered bedrock features in isolated exposures, elevated plateaus and

elongated ridges (drumlins, and other glaciofluvial outwash features) within the mine LAA. Permafrost sensitive landforms may be determined based on potential high water and ground-ice content, high frozen bulk density of soil, fine-grained strata with high silt content, position in the landscape, and slope types. Eskers are the most prominent uncommon landforms within the LAA. They are isolated topographic features, but three esker-related landforms have been identified within the mine LAA.

The Project site is located within the zone of continuous permafrost. Thickness of the active layer is highly variable from 1 m in surficial sediments to 5 m in bedrock outcrops. The ground-ice content of permafrost soil and rock is expected to be less than 10%.

Environmental Effects Assessment for Terrain

Change in Permafrost Conditions and Terrain Stability

Two factors that determine change in permafrost are ground temperature and the volume of ground-ice within the permafrost overburden. Ground temperature is influenced by several factors: air temperature, type and thickness of vegetation cover, organic soils insulation, rock type, snow cover, and terrain slope. Site and vegetation clearing, potential change in terrain slope, modification of surface water and drainage patterns, changes in subsurface water flow and any destructive activities such as blasting may result in changes in permafrost conditions and terrain stability.

Project activities that cause surface and subsurface disturbance can affect vegetation cover, organic soil insulation and frozen overburden materials, which can change the overall permafrost conditions and its distribution, and terrain stability. This can in turn lead to a change in the abundance and distribution of various landforms within the Project area.

Surface disturbances from construction and operation related activities will affect about 803 ha (or 2.2%) of the total 36,240 ha within the mine LAA. This will be caused by the loss of vegetation and organic soil due to removal (645 ha; 1.8% of the LAA) and burial (158 ha; 0.4% of the mine LAA). Changes in permafrost conditions and terrain stability—as a result of the loss of vegetation cover and organic soil—will be confined to the Project footprint and will occur primarily during construction, although effects are expected to continue through operations.

The proposed North All-Season Road alignment is expected to be 114 km long and approximately 24 m wide and will extend from the Kiggavik mine site to the Baker Lake dock site facility. The road will be built with rock material placed on top of the existing terrain (fill method), which will protect permafrost and prevent terrain stability issues. The proposed road is designed and routed on higher ground as these areas tend to contain less ground-ice, fewer drainage areas to cross, are less prone to snow drifts, and generally contain more bedrock, as well as suitable quarry locations. Routing the proposed road on higher ground will reduce geotechnical issues and road fill required during construction. This will also reduce potential maintenance issues (e.g., snow drifts) throughout the life of the Project.

Overburden materials at the dock site facility will be removed and stored. Following removal of the overburden, a site pad will be constructed to provide thermal protection to the underlying permafrost layer. Construction of the dock site facility is estimated to disturb an area of approximately 25 ha.

Mitigation measures will be implemented in two ways: mitigation by design and discipline-specific mitigation. Project design measures include minimizing the Project disturbance footprint and the number of drainage areas affected by the Project components and activities, and avoiding surface disturbance in high ground-ice areas to reduce potential for deepening the thaw depth and associated thaw settlement and terrain stability. Discipline-specific mitigation include the consideration of Project activities such as construction in permafrost sensitive areas during the winter time where feasible, controlled vehicular traffic along roads, planning of proper culvert location and construction and maintenance of roads susceptible to excessive groundwater seepage. Other mitigation measures include sustaining safe construction and operation practices within and adjacent to the Project footprint, management of drainage system around infrastructure, insulation of infrastructure, and use of coarser materials for road construction.

With implementation of the mitigation measures, residual environmental effects of the Project on permafrost conditions and terrain stability are expected to be low in magnitude, site specific, long term and reversible. The level of confidence in this prediction is considered high as these mitigation measures are widely used and well accepted practices for construction and operation of mining projects in areas of continuous permafrost in the Canadian Arctic. The potential environmental effects of changes in permafrost and terrain stability are predicted to be below the threshold for loss in terrain and, therefore, are predicted to be not significant.

Change in Landforms

Construction and operation activities, including excavation, placement of structural foundations, road construction, airstrip construction, pads and quarrying, will cause surface disturbances that can lead to a change or direct loss of surface materials due to stripping or burial of surficial deposits associated with landforms. This can lead to a change in the quantity of common landforms and the loss or change in uncommon landforms such as eskers. Project activities can also lead to changes in permafrost conditions, which can cause a loss or change in permafrost sensitive landforms.

Mitigation measures to reduce and/or eliminate Project effects on landforms will take place during the Project design and include minimizing Project disturbance footprint, avoidance of uncommon landforms, and reduction of the use of glacioflucial landforms. Project design features to prevent landforms susceptible to excessive surface and subsurface water seepage will be implemented, which includes the planning and design of proper culverts, where necessary.

Changes in landforms as a result of the Project will be confined to the Project footprint within the mine LAA and will occur primarily during construction and, to a lesser extent, during operations and closure of the Project. Of the total surface areas covered by alluvial, glaciomarine, bedrock and glacial (till and moraine) landforms within the mine LAA, about 0.6% (22 ha), 0.4% (less than 1 ha), 3.8% (68 ha) and 2.4% (720 ha) will be lost as a result of surface disturbances, respectively. Approximately 2.2% of the total surface area covered by common depositional landforms within the mine LAA will be disturbed by Project activities.

Residual effects on landforms will be confined to within the North All-Season Road LAA and will occur primarily during construction. The construction of the road will involve the burial of common landforms. The total surface area of the North All-Season Road LAA encompasses approximately 52,032 ha. The estimated surface areas covered by alluvial, glaciofluvial, glaciomarine, bedrock and morainal (glacial till) landforms that are expected to be buried by the proposed road will comprise 6.65 ha (0.01%), 0.35 ha (less than 0.01%), 6.60 ha (0.01%), 65.76 ha (0.13%), and 148.02 ha (0.28%) of the total area of the North All-Season Road LAA, respectively.

No changes or loss of permafrost sensitive and uncommon landforms are expected to occur because glaciofluvial landforms will not be affected by the Project. With implementation of the mitigation measures, residual environmental effects on landforms are predicted to be low in magnitude, spatially limited (site specific), long term, will likely occur once, and irreversible. The level of confidence in this prediction is high because these predictions are based on experiences with similar projects in the Canadian Arctic. Also, the mitigation measures are widely used and well accepted practices for the construction and operation of mining projects in areas of continuous permafrost in the Canadian Arctic. Changes in common depositional landforms are predicted to be below the threshold and, therefore, are expected to be not significant.

Given the limited spatial extent of surface disturbance caused by the Project, residual effects on terrain are expected to be low and not significant. Effects on terrain stability, permafrost conditions and landforms due to construction and operation activities are not expected to contribute to cumulative effects on terrain in the RAA.

A monitoring system of terrain will be established during all phases of the Project and include thaw-depth monitoring within the mine, mine affected areas and roads, soil sampling and laboratory analysis, and routine visual field inspection of terrain slope conditions and landforms within the mine development and adjacent areas. Slope stability monitoring devices will be installed, if necessary.

Effects of Climate Change on Terrain

Climate change is expected to cause long-term effects on permafrost conditions and the stability of terrain in the Canadian Arctic. However, the magnitude and extent of these effects will depend on the degree and rate of warming. Thermal modeling results for long-term (2000 years) climate scenario for the Project area indicate that if the mean annual ground surface temperature rises, a change in permafrost depth will be evident at the base but not at the surface. Undisturbed ground surfaces (natural ground) will likely retain permafrost after an assumed climate warming trend of 5°C in the mean annual ground surface temperature. With implementation of permafrost design features with due consideration of predicted long-term climate change in the Arctic, changes to terrain are anticipated to be minor relative to the baseline condition and the residual effects are predicted to be not significant.

Scope of the Assessment for Soils and Vegetation

Existing Environment – Soils

Soils near the Project are influenced by continuous permafrost within the top 2 m of the soil surface. Twelve soil types for the Turbic Cryosol, Static Cryosol and Organic Cryosol classification subgroups have been documented in the RAA.

The soils consist predominantly of a shallow organic veneer overlying fine to coarse textured glacial till blankets, which vary in thickness from less than 1 m on bedrock ridges to more than 4 m in depressions. The average depth of topsoil available for reclamation salvage (organic layers plus organic enriched mineral soil, or A horizon) is approximately 11 cm, with a minimum of 3 cm in upland lichen tundra, heath upland and heath tundra areas (Regosolic Turbic Cryosols), and a maximum of 31 cm in low-lying wet graminoid and graminoid tundra areas with thick peats (Organic Cryosols). Approximately 54% of the topsoil depth in any given area is peat organic material. The till-derived mineral fraction of the soils is medium textured, with coarse fragment size typically ranging from gravel to cobble. Coarse fragment content is typically low at the surface, and increases with depth.

Three soil samples from the Kiggavik lease area had elevated trace element concentrations per the Canadian Council of Ministers of the Environment (CCME) Industrial soil guidelines (CCME 2009); one soil sample had an elevated arsenic concentration, and two samples had elevated molybdenum concentrations. Four out of the five peat samples collected in the Kiggavik lease area had elevated concentrations of boron relative to the Industrial soil guidelines. No samples from the Sissons lease area had elevated trace element concentrations. No sample locations had elevated radionuclide concentrations.

Environmental Effects Assessment for Soils

Change in Soil Quality

Changes in soil quality use results from air quality modeling to estimate potential acid inputs (PAI) generated by the Project at the proposed mine sites, as well as dust deposition (metals and radionuclides) generated by Project activities. Adverse effects on soil quality due to changes in the concentration of the Constituents of Potential Concern (COPC) are compared to CCME criteria and to baseline conditions. Potential changes in soil quality due to admixing, compaction, and erosion are based on the nature and extent of construction activities.

Mitigation measures for changes in soil quality will focus on reducing and/or preventing air emissions, soil contamination from radiation, soil admixing due to construction activities, and soil compaction and erosion throughout the duration of the Project. Mitigation measures to suppress dust and reduce the amount of dust created by Project activities will also be implemented.

Air quality modeling predicts that changes in COPC concentrations in soils will be below the CCME (2009) Soil Quality Guidelines. Approximately 81 ha outside of the Kiggavik mine site may be exposed to PAI values above the critical threshold value. Soil compaction will be kept within the confines of the Project footprint, and will be low in magnitude as the majority of soil types identified within the Project footprint are less prone to compaction due to their sandy texture and amount of coarse fragments. With implementation of the mitigation measures, any residual effects caused by soil admixing and soil erosion are predicted to be negligible.

Project residual effects on soil quality due to air emissions and dust deposition are expected to be low in magnitude and localized in geographic extent, and will likely be continuous in frequency and long term in duration but reversible. Residual effects of soil compaction are predicted to be low in magnitude, site specific in geographic extent, medium term in duration, continuous in frequency, and reversible. Potential residual effects on soil quality due to soil admixing and soil erosion are anticipated to be negligible. Overall, changes in soil quality caused by the Project are predicted to be not significant.

Monitoring of soil quality through chemical analysis of soil samples, air emissions and dust deposition will occur throughout the duration of the Project. Comparisons will be made between chemical analyses results from soil samples to both air emissions and dust deposition results, as well as to baseline values and CCME guidelines to identify and reduce adverse effects on soil quality caused by the Project.

Change in Soil Quantity

Changes in soil quantity are based on the maximum predicted area to be disturbed by the Project. Effect mechanisms that can contribute to changes in soil quantity during Project development include topsoil stripping, soil erosion, soil movement, and soil burial.

Mitigation measures identified to reduce and/or prevent Project-related effects on soil quantity include construction and storage plans, as well as soil movement for preserving stripped topsoil for reclamation purposes. Project design features, erosion control structures, and measures to limit the amount of soil buried during construction will also be incorporated into the Project to reduce soil loss.

Depending on the Project development option selected, the Project will disturb an area ranging between 931 ha and 1,205 ha, which represents less than 1 % of the combined LAAs. Of this area, approximately 645 ha will be lost due to topsoil stripping, and between 286 ha and 560 ha will be lost due to soil burial.

Project residual effects on soil quantity are expected to be low in magnitude, site specific in geographic extent and reversible. The duration of time over which effects on soil quantity will be detectable will vary depending on the effect mechanism, ranging between short term (i.e., soil movement), medium term (i.e., soil erosion, topsoil stripping) and long term (i.e., soil burial). Effects on soil quantity are expected to predominately occur during the construction phase, although soil erosion may occur sporadically throughout the duration of the Project as a result of weather events interacting with the Project. With a high degree of confidence, it is predicted that residual effects of the Project on soil quantity will be not significant.

An environmental monitor will be on-site during the construction phase to assist AREVA personnel and contractors with implementing mitigation strategies to reduce the effects of the Project on soil quantity, such as topsoil stripping and soil storage activities. Dust deposition monitoring will occur throughout the duration of the Project to identify and mitigate potential effects on soils.

Effects of Climate Change on Soils

Climate change will likely have the most pronounced effect on soil quantity as a result of increased soil erosion due to changes in temperature, precipitation, and wind. Soil susceptibility to erosion would likely increase with increases in temperature, decreases in precipitation, and increases in duration and magnitude of wind events. Soils exposed by the Project (e.g., overburden pile) would likely be most susceptible to soil loss.

Existing Environment – Vegetation

The Project region is dominated by tundra vegetation interspersed with lichen-dominated bedrock outcroppings and boulder fields. Tundra vegetation is continuously underlain by permafrost and characterized by short shrubs such as dwarf birch, willows and heath species, as well as sedges and grasses, herbs, mosses and lichens. Fifteen ecological land classifications (ELC) map units have been identified within the LAAs and RAA.

Wetlands (including all waterbodies and watercourses) are identified within the RAA. The Wet Graminoid ELC map unit is used to identify areas containing wetland vegetation that are assumed to be waterlogged throughout the year. Approximately 20.5% (9,205 ha) of the LAA consists of wetlands, compared to 32.8% (322,287 ha) of the RAA.

Inuit Qaujimajatuqangit (IQ) studies indicated that certain plant species are of particular value to Inuit for food, medicine, shelter and other human uses. The most commonly mentioned plant species valued by Inuit during the public engagement sessions include black berries (*Empetrum nigrum*), cloudberries (*Rubus chamaemorus*), blueberries (*Vaccinium uliginosum*), and cowberries (*Vaccinium vitis-idaea*). Eleven of the 15 ELC map units identified contain these species.

Plant tissues samples were collected and analyzed to determine baseline analyte concentrations that will be used for comparison during environmental effects monitoring programs.

Environmental Effects Assessment for Vegetation

Change in Vegetation Abundance and Community Diversity

Vegetation abundance and community diversity could be adversely affected by site clearing, vegetation burial due to placement of infrastructure, and the introduction of invasive species.

Mitigation to reduce and/or prevent Project-related effects on vegetation abundance and community diversity include measures to prevent destruction of sensitive species during Project development, as well as efforts to limit the amount of vegetated areas affected by site clearing and vegetation burial. The preservation of the vegetation seedbank within the stripped topsoil will facilitate natural regeneration of native vegetation to reclaimed areas, with progressive reclamation occurring throughout the life of the Project. The use of waterbodies and watercourses in selecting routing for the winter roads routing is an important consideration in limiting the amount of vegetation disturbed by the proposed access roads. Prevention measures for introduction of invasive and/or non-native vegetation will also be employed through the Project.

Depending on the Project development options selected, between 1,449 ha and 1,708 ha of upland area that supports vegetation will be disturbed by the Project. Of this disturbed area, between 168 ha and 175 ha (0.4 % to 0.5 %) of the wetland area within the LAA boundaries that supports vegetation is predicted to be affected by the Project. Heath tundra is the ELC map unit likely to be most affected by the Project, with a total disturbed area ranging between 685 ha and 813 ha (1.9% and 2.8 % of the total area affected).

Regardless of the development options selected, the predicted residual effects of the Project on vegetation abundance and community diversity are anticipated to be low in magnitude, site specific in geographic extent, and occur primarily during the construction phase. Residual effects will be long term in duration but will be reversible with reclamation. As such, the change in vegetation abundance and community diversity is predicted to be not significant.

Monitoring for changes in vegetation abundance and community diversity will occur throughout the duration of the Project. An environmental monitor will be on-site during all phases of the Project to work with AREVA personnel and contractors to meet and comply with environmental regulations associated with vegetation. Permanent sampling plots will be established around the Project Footprint and adjacent to the proposed access roads. These sampling plots will be routinely surveyed and assessed to measure potential changes in vegetation abundance and community diversity. Monitoring for invasive species will be completed throughout the duration of the Project, and, if identified, attempts will be made to remove any invasive species within or adjacent to the Project footprint.

Change in Vegetation Quality

Construction and operation activities of the Project will affect the quality of vegetation within the mine LAA as a result of air emissions from fossil fuel combustion and dust deposition. Air quality modeling predicts the effects of potential acid inputs (PAI), nitrogen oxides (NO_x), and sulphur dioxides (SO_2) on vegetation quality. Dust deposition modeling estimates changes in the concentrations of COPC within different classes of vegetation (i.e., berries, browse [e.g., willow, birch], forage [e.g., sedges, grasses], and lichen). These estimates are used to evaluate whether these changes will be within phytotoxicity limits.

To reduce the effects of air emissions on vegetation, all industrial machinery and equipment, and diesel-powered generators will meet the federal air emission standards. Low sulphur diesel fuel will be used to reduce SO_2 fumigation. The acid plant will be the largest producing unit of SO_2 associated with the Project. As such, a scrubber will be installed on the exhaust stack to remove particulates, acid mist and excess SO_2.

During the detailed design of the roads, efforts will be made to use non-calcareous materials from quarry sites to minimize dust-prone aggregate from being used during road construction. During open pit mining, blasting patterns will be used to control the dispersion of materials as well as dust. Where possible, blasting may also be avoided on days where dust dispersion

outside of the Project footprint is anticipated to be excessive due to the prevailing winds speeds. Dust suppression will involve spraying water from a tanker truck affixed with either a spray nozzle or spray bar onto dust-prone areas. If water spraying is not effective in preventing dust occurrence, additional dust suppression techniques will be investigated and implemented. Speed limits around the mine site and along all roads will be imposed to reduce airborne dust from vehicular and other equipment traffic.

About 81 ha of vegetation adjacent to the Kiggavik mine site, representing about 0.2% of the total mine LAA, will likely be exposed to PAI above the threshold value of 0.25 keq/ha/year. Dust deposition (measured as Total Suspended Particle [TSP]) above the threshold of 0.25 g/m2/year will affect about 20 ha and 16 ha at the Kiggavik and Sissons mine sites, respectively. The proportion of ELC map units potentially exposed to dust above this threshold value represents about 0.08 % of the mine LAA. No effects on vegetation quality are expected as a result of exposure to NO_2 or SO_2 from the Project because the predicted incremental annual maximum concentrations are below benchmark guidelines.

Predicted concentrations of COPC in browse and forage are predicted to be below the minimum available phytotoxic concentrations, with the exception of zinc in browse and forage and cobalt and copper in browse. However, there is not expected to be a significant change in the concentration of COPC in these species relative to baseline and the concentrations do not exceed upper thresholds. Consequently, no adverse effects on vegetation quality are expected to occur. There is the potential for a measureable change in the concentrations of several COPC in lichen at the Kiggavik mine site. The effect that the measurable change in COPC will have on lichen is unknown, as appropriate benchmarks for determining change in lichen are unknown. However, at AREVA's McClean Lake mine in northern Saskatchewan, there is an abundance of reindeer lichen at sampling locations exposed to increased COPC concentrations, and no obvious signs of stress to lichen have been reported.

Project residual effects on vegetation quality are expected to be low in magnitude, except for dust created during mining operations when effects are likely to be moderate. While changes in vegetation quality due to dust deposition are expected to be local in geographic extent, effects from air emissions will likely be more regional in extent. The residual effects are anticipated to occur continuously throughout the duration of the Project and the effects will be long term in duration but reversible. Therefore, changes in vegetation quality are predicted to be not significant.

Effects of Climate Change on Vegetation

Climate change can influence Project effects on vegetation. An earlier snowmelt that extends the growing season due to temperature increases can accelerate any potential changes in vegetation abundance and community diversity caused by the Project. Changes in vegetation composition from a tundra sedge community to either a graminoid or shrub community in areas

adjacent to human development have been documented. Climate change has the potential to facilitate and accelerate this change.

Climate change may also provide more favourable growing conditions for non-native species, especially in areas disturbed by the Project. While non-native species that are inadvertently introduced by the Project may not establish and proliferate due to the adverse conditions that currently occur, climate change may facilitate changes in conditions that promote their growth.

Scope of the Assessment for Wildlife

Caribou and muskox are the indicators of the terrestrial wildlife and habitat effects assessment. Other terrestrial wildlife present in the RAA occur at low densities so that a change from baseline condition would be undetectable or effects would be similar to effects on caribou and muskox. Lapland longspur and long-tailed duck are the indicators for Project effects on migratory bird habitat and health because they represent both upland songbirds and waterbirds. Peregrine falcon is the indicator for raptors because they habitually return to nest within the same territories for many generations. Short-eared owl, grizzly bear and wolverine are included in the effects assessment because they are wildlife species at risk.

Caribou and Muskox

Key issues related to effects on caribou and muskox are:

- direct effects of increased mortality risk from potential vehicle collisions and cumulative effects from increased harvester access from the all-season access road
- reduced habitat availability from the Project footprint that results in a direct loss of foraging habitat, and sensory disturbances that result in an indirect loss of functional habitat
- change to seasonal movements from physical structures (e.g., road embankment, open pits, buildings) and sensory disturbances that could directly affect seasonal movement
- change in health as a result of ingestion of contaminants (e.g., consumption of forage mixed with dust)

Only caribou are assessed for effects on movement because muskox do not make traditional seasonal migrations from wintering to calving area; consequently, changes to muskox movement are covered in the assessment of habitat use.

Key Project components related to these potential effects include site clearing (habitat loss), mine operation (reduced habitat effectiveness), road construction (habitat loss) and operation (mortality and reduced habitat effectiveness), and milling (noise and dust and influence on habitat effectiveness and dust effects on forage and ultimately wildlife health).

Increased cumulative mortality risk is considered significant if herd-specific mortality is increased beyond a level of sustainable harvest. There is no known existing standard or threshold for determining a significant loss of habitat for caribou or muskox. Based on professional opinion, experience from other northern projects, and knowledge of caribou and muskox ecology, Project effects on habitat availability are considered significant if greater than 5% of caribou growing or winter range becomes unsuitable for use by caribou, or muskox wildlife management unit MX/21 becomes unsuitable for use by muskox. In absence of published thresholds, effects on movement are considered significant if greater than 10% of the animals in a herd are diverted by Project activities such that the animals do not arrive at calving grounds or wintering areas. For health, the estimated exposure to both non-radioactive contaminants and radioactivity received by the biota, considering both baseline and Project emissions, is compared to levels that are protective of mammals.

Mortality Risk — Increased mortality risk is quantified by determining the caribou and muskox herds that are most likely going to be exposed to increased Project-related collisions (direct effect) and cumulative hunter harvest west of the Thelon River during the snow-free season. Information used to assess the effects included population status of trends of herds, current harvest levels, and identification of Total Allowable Harvest (TAH) limits. The all-weather road option is the focus for assessing potential increased cumulative mortality risk on caribou because it is the option that would allow hunters access to a previously inaccessible area during the ice-free season, and caribou harvest currently does not have a TAH.

The Qamanirjuaq herd is expected to interact with the Project during the post-calving aggregation and summer dispersal periods, and the Baker Lake (Resident) herd is expected to interact with the Project during the winter. Muskox within wildlife management unit MX21 are expected to be found in the RAA year round. The RAA has been traditionally used for hunting year round. Based on harvest location statistics collected as part of the Nunavut Wildlife Management Board Harvest Study, relatively few caribou have been harvested recently in the RAA. There is no available information on trends or proportions of mortality from natural causes such as disease or predation.

Mitigation for mortality is the combined responsibility of AREVA, other parties, and regulatory agencies. AREVA can implement a number of control measures to limit harvest along the road. These include controlled public access, no-hunting buffers, temporary shut downs, and reduced speed limits. Other agencies may be interested in monitoring harvest and populations, and establishing TAH limits. Ultimately, the potential cumulative additional harvest of caribou could require mitigation and management intervention by management authorities.

Following mitigation, it is predicted that residual effects on caribou mortality risk from the mine and access road options will be not significant. The mine and winter access road options are expected to result in not significant adverse effects on Qamanirjuaq caribou because these caribou should be mostly absent from the RAA during the winter season. The all-weather road has the potential to provide access to the RAA during the snow-free season when Qamanirjuaq caribou are in the area, which could increase the proportion of Qamanirjuaq animals taken only

in the late July/August season. However, application of mitigation measures (i.e. access control) will reduce the potential for increased mortality risk from harvest. There is a low potential for direct mortality risk from collisions with caribou along the access roads. Collisions with vehicles along the winter roads will be very unlikely, as reduced speed limits should allow vehicles to stop quickly if caribou are on the road. The all-weather road has faster speed limits, but vehicles should still be able to avoid collisions with caribou, particularly with communication among vehicles travelling the road.

The contribution of the Project to cumulative effects on mortality risk to caribou, and ultimately to the sustainability of the Qamanirjuaq and Baker Lake caribou herd populations will be not significant. While access options could have an effect on caribou harvest, it is not clear if that harvest will be additive or compensatory to what is already harvested by Baker Lake Hunters. The Qamanirjuaq herd seems to be the herd at greatest risk of increased harvest as a result of harvester access during the ice-free season. However, it appears that only a small portion of the herd is found in the RAA when the road provides access, and they are only in the area for a brief time. It is possible that tens of additional caribou could be harvested in the brief time that they are in the RAA. However, the determination of this possible effect is based on broad estimates of both current harvest rates and current caribou population numbers. Better knowledge of both is necessary in order to increase the certainty for effects prediction.

Compliance and environmental monitoring for change in mortality to caribou and muskox can include AREVA's 1) support of a Hunter Harvest Study to help determine total harvest by herd; 2) participation in the Government of Nunavut (GN)-led caribou collaring program to determine seasonal distribution by herd; 3) support of a GN-led population estimate survey to determine regional herd population trends; and 4) Project-specific caribou monitoring programs (ground-based observations).

AREVA considers it a high priority to work with interested parties on implementing effective and consistent mitigation to manage the potential increased mortality risk as a result of the all-season road access.

Habitat — A habitat unit index is used to assess the overall loss of caribou and muskox habitat availability within the RAA. The index is based on assigning a ranked value to each habitat class (i.e. high=3, moderate=2, low=1, nil=0). All ELC units within the Project footprint become of "nil" quality once the Project is constructed. The winter road options will remove habitat in winter, but the habitat will be available again each summer when the road is decommissioned. Indirect loss of habitat is assessed for reduced habitat quality for growing and winter seasons within the mine site and access road options. Habitat quality within the mine site Zone of Influence (ZOI) is reduced by two classes to a minimum of low within 7 km of the mine footprint, and by 1 class to a minimum of low within 14 km of the mine footprint. Habitat quality within each access road option ZOI is reduced by two classes to a minimum of low within 1 km of the access road footprints, and by one class to a minimum of low within 4 km of the access road footprints.

AREVA will mitigate potential adverse effects on caribou and muskox habitat by: 1) minimizing the Project footprint, 2) minimizing Project activities outside of the footprint; 3) reducing road activity during important migratory seasons and during post-calving; 4) progressively reclaiming disturbed areas; 5) providing dust suppression along roads during dry summer periods; and 6) eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings.

Following mitigation, the Project will have a not significant effect on caribou and muskox growing and winter season habitat. Habitat will not be reduced by more than the 5% significance threshold in the seasonal ranges. For caribou, the mine and all road options will cause a habitat loss of less than 1% within the range of the focal caribou herd. For muskox, the mine and all road options will cause a habitat loss of less than 5% within the Government of Nunavut's muskox management unit.

Currently, there are few human activities in the region that affect wildlife. The Meadowbank mine and regional communities are the greatest sources of habitat loss for wildlife. The addition of the Kiggavik Project to these disturbances is not expected to measurably reduce the amount of caribou and muskox habitat. Mineral exploration is currently not causing substantive loss of habitat. Although there is the potential for future mine development in the region, given the history of such developments, the likelihood of multiple future mines existing at the same time as the Project is low. The cumulative change to habitat availability for caribou and muskox is, therefore, assessed as not significant.

AREVA will monitor the Project footprint on an annual basis to assess the footprint area for changes in habitat availability. Continued contributions to a GN-led caribou collaring program will provide future information on the response of caribou to habitat disturbance in the Kivalliq region.

Movement — Caribou migration between calving grounds and winter range is the focus of the assessment of Project effects on animal movement. Minimizing effects on caribou migration is an important component for reducing Project effects on wildlife movement. Muskox move at relatively small scales (i.e., no long distance migration) between available habitats within their range and their movements are less directional and predictable than those of caribou. The assessment of Project effects on muskox habitat use covers potential Project effects on muskox movement.

The Project could affect caribou migration to calving grounds in spring or winter range in fall through construction of infrastructure and human activities that change, restrict or block caribou movement across the landscape.

Information used to assess Project effects on caribou movement comes from caribou collar data, IQ studies, and baseline wildlife studies. The potential effect of the Project on caribou movement is assessed by examining possible interactions with the Project during spring and fall

migrations. Three assumptions are made the assessment using collar data: 1) the collar data are representative of the entire herd; 2) caribou movement between collar relocation is a straight line; and 3) caribou movement during the collaring period reflects movement in the future. The number of caribou that crossed the assessment areas were counted to get an indication of potential caribou interaction with the Project during migration. Also, water crossings within 10 km were identified.

AREVA will mitigate effects on caribou movement by: 1) minimizing road embankment height of the all-weather road; 2) snow management that avoids long continuous cuts or piles of snow that could restrict spring migration across roadways; 3) reducing leg entrapment risk to caribou during fall migration by constructing roads from finer material; 4) avoiding construction activities within 10 km of designated water crossings from 15 May to 1 September, in accordance with the DIAND Caribou Protection Measures; 5) minimizing the use of fencing and, where required, minimize the lengths of fencing unless required for safety; and 6) implementing temporary road shutdowns if large numbers of caribou are observed migrating through the area.

Project residual effects on caribou movement will be not significant. Only small portions of the Qamanirjuaq herd are expected to interact with the Project during migration and the Project is not within 10 km of any designated water crossing. Residual effects on movement are not expected to be detectable and therefore will not contribute to cumulative effects.

AREVA may conduct the following monitoring for change in movement of caribou and muskox: 1) continued contributions to a government-led caribou collaring program; 2) monitoring caribou use of water crossing that are within 10 km of Project activities; and 3) seasonal monitoring of caribou movement prior to caribou entering the RAA as a proactive way of providing information that will advise temporary shutdown of traffic on roads.

Health — Emissions from the Project can affect the concentrations of COPC in the environment (e.g. water, soil, vegetation), which in turn will affect the exposure of caribou and muskox as they consume these items. The potential for these emissions to cause adverse effects in the populations of caribou and muskox is evaluated. The COPC used in the assessment include uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, and zinc. The exposure to COPC are estimated using the predicted environmental concentrations and assumptions about how much the caribou and muskox consume. The amount of time that the wildlife spend in the area is also an important factor. The results show that exposure to caribou or muskox is not expected to exceed exposure levels associated with adverse effects; therefore, no adverse health effects are expected on these biota.

Climate Change — Climate and ultimately, weather, directly influences the body condition of caribou, which in turn affects survival and mortality rates. Caribou survival is influenced by a number of climate-related parameters at different times throughout the year. Climate variability can influence factors that affect caribou mortality directly, such as summer insect harassment,

or indirectly, such as winter severity and spring snow free date. If a suite of negative climate conditions for caribou occurs (i.e., deep winter snow, hard snow crust, late spring snow free date, and extreme summer insect harassment), survival rates will undoubtedly decrease from baseline conditions. However, these effects will likely not be detectable within the 20 to 30 year life of the Project.

Effects on caribou and muskox populations may occur gradually throughout the life of the Project, yet it is largely unknown how or if wildlife will be able to adapt to these conditions. Due to the relatively short life of the Project, it is unlikely that climate change will increase Project effects on terrestrial wildlife or habitat.

Raptors

Peregrine falcon is the focus for the effects assessment on raptors. Other raptors that occur in the RAA either occur at low densities and a change from baseline condition would be undetectable or effects would be similar to effects on the indicator species. Activities during construction, operation and closure have the potential to affect the habitat, nest productivity and health of raptors in the RAA.

Key issues related to effects on peregrine falcons include: 1) reduced habitat availability from the Project infrastructure footprint that results in a direct loss of foraging habitat, and sensory disturbances that result in an indirect loss of functional habitat; 2) indirect effects of reduced nest site productivity from sensory disturbances from mine operations and road traffic at nests close to these activities; and 3) change in health due to radionuclide and metal content transfer through the food chain.

Based on professional opinion, experience from other northern projects, and knowledge of raptor ecology, Project effects on habitat availability are considered significant if greater than 10% of the habitat units in the RAA are directly affected by Project activities. A Project effect on productivity is considered significant when average productivity for the nests located to date in the RAA drops below 1.25 chicks/territorial pair/year. For health, the estimated exposure to both non-radioactive contaminants and radioactivity received by the biota, considering both baseline and Project emissions, is compared to levels that are protective of birds.

Habitat — The Project footprint will result in a direct loss of raptor foraging habitat. The footprint is expected to provide no usable habitat for raptors once the Project is constructed. The Project will also result in an indirect loss of raptor forage habitat because of human disturbance (presence, noise, and movement) in proximal habitats. There are no expected losses of nest sites.

To assess the overall loss of peregrine falcon habitat availability within the RAA, habitat types are ranked as nil, low, moderate and high quality habitat. most of the RAA is considered high to moderate quality foraging habitat. Nine peregrine falcon nest sites were found, all located on the rocky cliffs within or adjacent to the north all-season road access route.

AREVA will mitigate potential adverse effects on raptor habitat through: 1) minimizing the Project footprint; 2) minimizing Project activities outside of the footprint; 3) progressively reclaiming disturbed areas; 4) providing dust suppression along roads during dry summer periods; and 5) eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings. The Project footprint is reduced with the winter road options, thus habitat loss and the likelihood of the Project acting cumulatively with other projects in the Kivalliq region is reduced.

After mitigation, the mine site and all-weather road will result in a direct loss of 1,704 ha of previously usable foraging habitat. The Project is anticipated to reduce the availability of foraging habitat by 5.8% of the habitat units within the RAA. Given the size of the expected ZOI, all effects are expected to be confined within the LAAs. The loss of habitat is reversible as prey species use previously disturbed areas as the mine site is reclaimed actively and naturally. The road option that will have the greatest effect on raptor habitat is the all-weather road because of the larger footprint and larger ZOI. The extent of the Project footprint will be monitored on an annual basis to confirm habitat loss predictions.

The Project is not anticipated to act cumulatively with other projects to cause a biologically relevant reduction of habitat availability in the region.

Nest Productivity — Nest productivity is considered stable if productivity remains at an average of 1.25 chicks/territory/year. Because falcons annually return to cliff nest sites over many generations, the limited number of sites (9), and the relative ease of follow-up monitoring, the effects assessment is addressed on a territory by territory basis for the north all-weather road option only. Winter road options do not interact with breeding peregrine falcons. All nesting sites are within or proximal to the north all weather road LAA.

Continued exploration activities, construction, and operations have the potential to interact negatively with peregrine falcons. Continued aircraft use at the site has the potential to disturb peregrine falcons. The degree of response to disturbance is associated with the stage of the breeding season. Key mitigation for ensuring continued productive nesting in the RAA includes no-disturbance around nest sites when activities must occur during the breeding season, construction outside of the breeding season when disturbance must occur near nest sites, and a no-fly zone for regularly occurring ferrying flights.

The effect of the Project on raptor nest productivity will be not significant. The Project footprint does not interact with known raptor nest sites, and reduced disturbance at nest sites during the breeding season is expected to reduce the potential for adverse effects on raptor nest productivity. During operation, no or very few raptors will be exposed to disturbance sufficient to affect the productivity of their nest.

Monitoring for change in raptor nest productivity will include individual nest site monitoring during construction to determine when territorial pairs are attempting to establish a territory and begin nesting (and thus establish a no disturbance buffer), and annual monitoring of territory occupancy, egg laying, egg hatching, and chick fledging (i.e., productivity) of the nests identified in the baseline study.

Health — Emissions from the Project can affect the concentrations of COPC in the environment (e.g. water, soil, small mammals), which in turn will affect the exposure of raptors as they consume these items. The potential for these emissions to cause adverse effects in the populations of peregrine falcon is evaluated. The COPC included in the assessment are uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, and zinc. The exposure to COPC can be estimated using the predicted environmental concentrations and assumptions about how much the peregrine falcon consume. The amount of time that falcon spend in the area is also an important factor. The results indicate that it is unlikely that exposure to peregrine falcon will exceed exposure levels associated with adverse effects in birds; therefore, no adverse health effects on raptors are expected.

Climate Change — Cumulative effects of climate change on raptors and habitat are expected to be negligible over the 20 to 30 year life of the mine. If peregrine falcons are affected by climate change, it will occur via indirect effects. A study in nearby Rankin Inlet, Nunavut, found a strong correlation between the highly variable breeding success of peregrine falcons and weather, especially summer rainfall and spring snowstorms. With increased variability in seasonal weather conditions, the long-term reproductive success of peregrine falcons could be compromised. However, this mechanism is expected to occur independently and is not expected to act in combination with any other Project-specific effects.

Migratory Birds

Lapland longspur and long-tailed duck are the focus of the assessment for migratory birds. Other migratory birds occur in the RAA and the expected Project effects will be similar to effects on lapland longspur and long-tailed duck. Key concerns include Project-related effects on habitat availability and health. Key Project activities related to these effects include site clearing (habitat loss), mine operation (reduced habitat effectiveness), road construction (habitat loss) and operation (reduced habitat effectiveness), milling (noise affecting habitat effectiveness and dust affecting forage and ultimately bird health).

Based on professional opinion, experience from other northern projects, and knowledge of migratory bird ecology, Project effects on habitat availability are considered significant if greater than 10% of habitat units in the RAA are affected. For health, the estimated exposure to both non-radioactive contaminants and radioactivity received by the biota, considering both baseline and Project emissions, is compared to levels that are protective of birds.

Habitat — The Project will result in a loss of migratory bird growing season habitat (e.g. nesting and post-fledging habitat). The Project footprint will make some habitat unavailable for migratory birds, while human activity associated with the Project could cause a functional loss of adjacent habitat. Effects on habitat from the Project could act cumulatively with similar effects from other human activity in the area.

A habitat unit index is used to estimate the overall loss of lapland longspur and long-tailed duck habitat availability within the RAA. The index is based on assigning a ranked value to each habitat class (i.e. high=3, moderate=2, low=1, nil=0). All ELC units within the Project footprint become of "nil" quality once the Project is constructed. The winter road options will not affect breeding bird habitat because the habitat will be available again each summer when the road is decommissioned. Habitat quality within the mine site and road ZOIs are reduced by two classes to a minimum of low within 2 km of the mine footprint, and by one class to a minimum of low within 3 km of the mine footprint.

AREVA will mitigate potential adverse effects on migratory bird habitat by 1) minimizing the Project footprint, 2) minimizing Project activities outside of the footprint, 3) progressively reclaiming disturbed areas, 4) providing dust suppression along roads during dry periods, and 5) eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings.

The effect of the Project on migratory bird habitat within the RAA is assessed as not significant. Predicted loss of available habitat for migratory birds due to the Project is less than 5% of the habitat units for both indicators and all road options. The magnitude of adverse effects of the Project on migratory bird habitat availability is rated as low during all Project phases and for all road options. The Project is expected to result in a detectable loss of habitat within the LAAs. The loss of habitat will be not significant as all migratory birds in the RAA will continue to have abundant suitable habitat available for foraging. The extent of the Project footprint will be monitored on an annual basis to confirm habitat loss predictions.

The Project is not anticipated to result in significant adverse effects on migratory bird habitat within the RAA. Although the residual effects of the Project on changes in habitat availability are not significant, the effects could act cumulatively with similar effects from other human activity in the region that affects migratory bird habitat. The cumulative effect of the habitat loss could reduce the overall availability of habitat for migratory birds in the region to a point that population-level effects occur.

Health — Emissions from the Project can affect the concentrations of COPC in the environment (e.g. water, soil, aquatic vegetation, insects), which in turn will affect the exposure of migratory birds as they consume these items. The potential for these emissions to cause adverse effects in the populations of migratory birds, represented by the lapland longspur and the long-tailed duck, is evaluated. The COPC included in the assessment are uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt,

copper, lead, molybdenum, nickel, selenium, and zinc. The exposure to COPC can be estimated using the predicted environmental concentrations and assumptions about how much the lapland longspur and the long-tailed duck consume. The amount of time that birds spend in the area is also an important factor. The results indicate that exposure to lapland longspur or the long-tailed duck is not expected to exceed exposure levels associated with adverse effects in birds; therefore, no adverse health effects on migratory birds are expected.

Climate Change — Determining the effects of climate change is complicated due to seasonal habitat use. Winter ranges are often in southern North America to South America, introducing an entirely different suite of climate-related effects that are beyond the scope of this assessment. Effects of climate change on migratory birds that seasonally occur within the RAA would likely be related to the occurrence of local weather conditions above or below normal (e.g. extreme frost or snow events in spring or summer). Indirectly, temporal deviations in environmental conditions (e.g., late snowmelt) could result in increased mortality due a lack of available forage food. An example of this is the diet of the lapland longspur, which consists of the previous season's berries and catkins when they first arrive in the early spring, and arthropods during summer. Climate change may alter the tundra vegetation from low-lying shrubs (e.g. berries) to taller deciduous shrubs, benefiting arthropod production and resulting in abundant summer forage, but decreasing the production of berries and catkins that are needed when the birds first arrive in the spring. These mechanisms are expected to occur independently, and are not expected to act in combination with any other Project effects. Although migratory bird habitat will be lost to the Project footprint, it is expected that climate change will not act cumulatively.

Species at Risk

The species at risk effects assessment focuses on short-eared owl habitat and health, and grizzly bear and wolverine health. Key Project components related to these potential effects include site clearing (habitat loss), mine operation (reduced habitat effectiveness), road construction (habitat loss), operation (reduced habitat effectiveness), and milling (noise and dust and influence on habitat effectiveness and dust effects on forage and ultimately health). Although no nest or dens sites have been observed in the RAA, all three species are expected to occur infrequently and at low numbers in the area.

Based on professional opinion, experience from other northern projects, knowledge of short-eared Owl ecology in arctic Canada, and the relatively low number of occurrences of the species in the region, Project effects on habitat availability are considered significant if greater than 10% of habitat units in the RAA are affected. For health, the estimated exposure to both non-radioactive contaminants and radioactivity received by the biota, considering both baseline and Project emissions, is compared to levels that are protective of mammals and birds.

Habitat — The Project will result in a loss of short-eared owl habitat. A habitat unit index is used to estimate the overall loss of habitat availability within the RAA. The index is based on assigning a ranked value to each habitat class (i.e. high=3, moderate=2, low=1, nil=0).

Mitigation measures that will be implemented to minimize effects on habitat availability for short-eared owl include: 1) all areas within the clearing footprint will be searched for nests prior to clearing activities that occur during the breeding bird season, active nests will be identified and for short-eared owl, and an 800 m radius no-disturbance buffer will be applied until nesting is complete and chicks have fledged; 2) all on-site observations of short-eared owl will be investigated to determine presence of nests sites, and active nests will be marked as described above with an 800 m radius no-disturbance buffer; and 3) reclamation will include the establishment of shrub cover, which will provide small mammal (prey) habitat and potential nesting habitat.

The Project will result in the long-term loss of some nesting and foraging habitat for short-eared Owls. The change in habitat will be measureable, but will be limited to the footprint (complete loss) and within the LAA (indirect loss). Reduced habitat effectiveness is reversible once operations cease. Overall, Project effects on short-eared owl nesting and foraging habitat will be not significant.

Health — Emissions from the Project can affect the concentrations of COPC in the environment (e.g. water, soil, fish, berries), which in turn will affect the exposure of Species At Risk as they consume these items. The potential for these emissions to cause adverse effects in the populations of grizzly bear and wolverine is evaluated; the assessment of raptors includes the potential exposure of the short-eared owl. The COPC included in the assessment include uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, and zinc. The exposure to COPC can be estimated using the predicted environmental concentrations and assumptions about how much the grizzly bear and wolverine consume. The amount of time that the wildlife will spend in the area is also an important factor. The results show that it is not expected that the exposure to the grizzly bear and wolverine will exceed exposure levels associated with adverse effects in mammals, in addition, no adverse effects are expected on the short-eared owl. Therefore, no adverse health effects are expected on Species at Risk.

Climate Change — Climate change occurs continuously at a global scale, and will likely have long-term effects on wildlife and habitats. Climate change could exacerbate effects on Species at Risk, especially if they are already subject to current environmental pressures. Effects of climate change on Project and cumulative effects on Species at Risk are expected to occur independently and are not expected to act in combination with any other Project-specific effects.

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GLOSSARY

Active Layer	A shallow zone above the permafrost table that thaws in the summer and refreezes each year.
Affinity	A natural liking or attraction.
Albedo	The ratio of the intensity of light reflected from an object to that of the light it receives from the sun.
Alluvial	Unconsolidated accumulation of stream-deposited sediments including sands, silts, clays or gravel.
Analyte	A chemical substance that is the subject of a chemical analysis.
Biomass	The amount of living matter in a given habitat.
Brunisolic	A type of soil that usually formed under forests.
Calcareous	Containing or resembling calcium carbonate; chalky.
Cobble	Coarse soil particles with size range from 75 mm to 300 mm according to the Unified Soil Classification System.
Committee on the Status of Endangered Wildlife in Canada	This committee uses the best available information on wildlife species (including scientific, community, Aboriginal Traditional Knowledge) to assess whether that species is at risk of extinction or extirpation in Canada.
Constituents of Potential Concern (COPC)	Metals and radionuclides that have the potential to adversely affect human health or the environment.
Contouring	To build in conformity with the landscape.
Critical load	A value used to protect ecosystems from acid deposition.
Crustal rebound	A post glacial process of rising of land masses that were depressed by the huge ice sheets during the last glacial period.
Cryosol	A type of soil that has permafrost within one metre of the surface.
Cryoturbation	Movement of surficial materials by heaving or churning as a result of frost action.
Decommissioning	To remove or retire from active service.
Endangered	A wildlife species facing imminent extirpation or extinction.
Equilibrium	A state of rest or balance between opposing influences.

Esker	A well- defined, long, narrow topographic ridge of sandy gravel to gravel material and other sediments deposited resulting from glacial deposition created by streams flowing beneath a glacier.
Felsenmeer	A type of morainal or glacial deposit characterized by low, gentle tomography and very bouldary surface. From the Danish “fjoeld-mark” or rock desert.
Frost wedging	Weathering of soil and rock due to repeated freeze-thaw cycle of water.
Fugitive dust	Particulate matter which becomes airborne and has the potential to adversely affect human health or the environment.
Fumigation	To expose an area to fumes.
Geomorphological process	Natural mechanisms of weathering, erosion and deposition that result in the modification of the surficial materials and landforms at the earth’s surface.
Geotechnical Conditions	Properties, behaviour and use of soil and rock.
Geotextile	A strong synthetic fabric used to retain an embankment.
Glacial till	Unsorted materials that have been deposited directly by the ice (glacier).
Glaciofluvial	Relating to materials moved by glaciers and subsequently sorted and deposited by streams of glacial meltwater.
Glaciolacustrine	Relating to materials released from the glacial ice deposited in layers when flowing glacial meltwater comes to rest, as in lakes and deltas.
Glaciomarine	Relating to materials released from the glacial ice come in contact with marine water and deposits.
Great Groups	Different kinds of soil that are developed under the same soil-forming processes.
Ground-ice	Any body of pure ice that forms in the soil.
Harrowing	Agricultural equipment with spike-like teeth or upright discs that is pulled across the land to loosen compacted soils.
Histic	A type of soil horizon that occurs at shallow depths and consists of poorly aerated organic soil material.
Hummocky	Formed from organic residues, either separate from or intermixed with mineral materials.

Hydrophytic	A plant that grows in water or very moist ground.
Ice-wedge	Ground-ice that forms vertically, tapering down to a point.
Igneous rock	One of the three main rock types according to their origin, which is formed as a result of the cooling and solidification of magma and lava at the depth of the earth's crust or on the Earth's surface.
Intrusive	Pertaining to the process of emplacement of magma in pre-existing rock.
Isopleth	A line drawn on a map through all points having the same numerical value, as of a population figure or geographic measurement.
Isostatic (rebound)	A post glacial process of upward movement of land masses. Post glacial crustal rebound is gradually being replaced by the term isoistatic rebound or isoistatic adjustment.
Kame	Isolated and irregular mounds of stratified ice-contact sediments, generally composed of sand, sometimes with gravel, pebbles and fine clays.
Laurentide Ice Sheet	A massive ice sheet in northern Canada formed due to fall in temperature at the beginning of the last glacial stage. It is one of the main three continental ice sheets, the others being the glacial complex in the High Arctic and the Cordilleran glacial complex.
Metamorphic rock	Rocks formed as a result of transformation of existing rocks (which may be of igneous, sedimentary or metamorphic origin) by partial or complete recrystallization under the action of heat and/or pressure.
Microtopography	The surface features of the Earth on a small scale.
Mitigation	The act of making a condition or consequence less severe; methods employed to reduce, offset, or reduce adverse effects of an activity on the environment.
Moraine	Glacial till deposited at the end, sides, or beneath the ice (glacier).
Negligible	So small or unimportant that it may safely be neglected or disregarded.
Organic	Composed of material that originates from living organisms.

Outwash	Coarse soil material, mainly sand and gravel, removed or "washed out" from glacier by melt-water streams and deposited near the ground.
Overburden	The amount of soil materials lying above the bedrock in the area of interest.
Particulates	Solid or liquid particles suspended in the atmosphere.
Passerine	A bird of the order Passeriformes, which includes more than half of all bird species; also known as perching birds
Periglacial	Near-glacial in the sense of either location or conditions.
Permafrost	Ground (soil or rock) that stays below 0 degrees Celsius for at least two years (continuous permafrost- a region where over 90% of the ground surface is underlain by permafrost).
Physiology	The branch of science concerned with the functioning of organisms.
Phytotoxicity	Inhibits plant growth or is poisonous to plants.
Plasticity	Ability of a soil to change shape continuously under an applied stress, and retain the new shape on removal of the stress.
Pore pressure	Pressure of water held in pores within a soil or rock.
Potential Acid Input (PAI)	A unit of measurement used to assess the level of acid introduced to a given area by deposition.
Precambrian	Geological time period, the earliest of the geologic ages, that covers the vast bulk of geologic time (approximately 88%), starting from the formation of Earth around 4.5 billion years ago to the beginning of the emergence of life-forms almost 600 million years ago.
Proliferation	Rapid growth or production of cells.
Propagule	Any form of various structures that can act as an agent of reproduction in vegetation (e.g., seeds, spores).
Quartzite	A hard metamorphic rock formed from sandstone under the action of heat and pressure.
Radionuclide	An atomic species in which the atoms all have the same atomic number and mass number, and are radioactive.

Relative biological effectiveness	A relative measure of the effectiveness of different radiation types at inducing a specified health effect. It is expressed as the inverse ratio of the absorbed doses of two different radiation types that would produce the same degree of a defined biological end point.
Riprap	Rock or other materials used to stabilize shorelines, streambanks, and/or streambeds to prevent erosion.
Scarified	To loosen soils using equipment.
Schist	A metamorphic rock formed by metamorphism at high temperature and high pressures.
Shear strength	An engineering term, which is used to describe the strength of the material (soli) against the structural failure or deformation.
Slump	Scoop-like scar slides as result of thaw flows in unconsolidated sediments developed by pereglacial processes in soil-ice mixtures.
Soil admixing	Involves the mixing of materials between soil horizons.
Soil compaction	The process by which a stress applied to a soil causes the soil to become denser as air is displaced from the pores between the soil grains.
Soil erosion	Involves the wearing of exposed soils due to climatic events, such as wind, precipitation, or water flow over a surface.
Solifluction	A type of mass movement whereby a layer of permafrost melts and moves down a slope.
Special Concern	A wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Species at risk	Those species identified by the Committee on the Status of Endangered Wildlife in Canada, or under the *Species at Risk Act* (SARA) as Special Concern, Threatened, Endangered, or Extirpated. The species are usually considered at risk because of declining populations, loss of habitat, and continued threats to their recovery.
Tailings	Crushed rock, water and chemicals remaining after the removal of the uranium from the rock.
Thaw subsidence	Subsidence resulting from the thaw behaviour of permafrost.

Surficial deposit	Loose deposits covering bedrock.
Tackifier	Chemical compounds used to formulate used to increase the stickiness of a surface.
Thaw settlement	An engineering term, which is used to describe the change in volume of thawing soil from both phase change (ice to water) and flow of excess water out of the soil.
Thermistor	A temperature sensing device used for the measurement of ground temperatures.
Thermokarst	A process of the thawing of subsurface ice confined to the upper part of the permafrost and related to subsidence of the earth's surface with the formation of the negative forms of hummocky, irregular relief.
Threshold	A level of change beyond which unacceptable adverse effects may potentially occur.
Tundra	A treeless landscape with a cold climate that exists in the polar regions and at high altitudes.
Tussock	A tuft or clump of growing grass.
Ungulate	A hoofed mammal. (e.g., caribou, muskox).
Valued environmental component	Attributes that are of cultural or ecological importance that interact with the Project.
Veneer	A thin cover of some material that is more desirable as a surface material that the underlying material.
Zone of Influence (ZOI)	An area surrounding an activity that is indirectly affected by that activity (e.g., noise, dust, visual disturbances).

ACRONYMS

µg ..... microgram
AENV ..... Alberta Environment
BQCMB ..... Beverly and Qamanirjuaq Caribou Management Board
CASA ..... Clean Air Strategic Alliance
CCME ..... Canadian Council of Ministers of the Environment
CDA ..... Canadian Dam Association
CEAA ..... Canadian Environmental Assessment Agency
COPC ..... Constituents of Potential Concern
COSEWIC ..... Committee on the Status of Endangered Wildlife in Canada
EARP ..... Environmental Assessment and Review Process
Eco-SSL ..... ecological soil screening levels
EIS ..... environmental impact statement
ELC ..... Ecological Land Classification
FHCP ..... Fish Habitat Compensation Plan
GNWT ..... Government of Northwest Territories
GN ..... Government of Nunavut
HHS ..... Hunter Harvest Study
HTO ..... Hunter and Trappers Organization
IQ ..... Inuit Qaujimajatuqangit
LAA ..... local assessment area
LOAEL ..... lowest observable adverse effect level
m agl ..... metres above ground level
mGy/d ..... milligray per day
MMER ..... Metal Mining Effluent Regulation
Nbe ..... non visible ice, well bonded with excess ice
Nbn ..... non visible ice, well bonded with no excess ice
Nf ..... non visible ice, poorly bonded or friable
NIRB ..... Nunavut Impact Review Board
NO_2 ..... nitrogen dioxide
NO_x ..... nitrogen oxide

NPC ..... Nunavut Planning Commission
NRC ..... National Research Council
NWT ..... Northwest Territories
ORV ..... off-road vehicle
PAI ..... potential acid input
RBI ..... relative biological effectiveness
SARA ..... *Species at Risk Act*
SI ..... screening index
RAA ..... regional assessment area
SI ..... screening index
SO_2 ..... sulphur dioxide
TAH ..... Total Allowable Harvest
TMF ..... tailings management facility
TSP ..... total suspended particle
Vc ..... visible ice, ice coatings on particles
VEC ..... valued environmental component
Vr ..... visible ice, random or irregularly oriented ice formations
Vs ..... visible ice, stratified or distinctly oriented ice formations
WHO ..... World Health Organization
WTP ..... water treatment plant
ZOI ..... zone of influence

1 INTRODUCTION

1.1 BACKGROUND

The Kiggavik Project (Project) is a proposed uranium ore mining and milling operation located in the Kivalliq region of Nunavut approximately 80 km west of the community of Baker Lake (Figure 1.1-1). The Project is operated by AREVA Resources Canada Inc. (AREVA), in joint venture partnership with JCU (Canada) Exploration Co., Ltd. and Daewoo International Corp.

Within the Kiggavik Project, there are two general site areas referred to herein as the Kiggavik mine site and the Sissons mine site. The two mine sites are located approximately 17 km apart. Three uranium ore deposits will be mined at the Kiggavik site: East Zone, Centre Zone and Main Zone. A uranium mill, related facilities, main accommodations, and landing strip will also be located at the Kiggavik site. The Sissons mine site has two uranium ore deposits to be mined: Andrew Lake and End Grid. Open pit mining will be used to extract the ore from the three Kiggavik deposits as well as the Andrew Lake deposit. Mining of End Grid ore will require underground methods.

All ore extracted from the mine sites will be processed through the Kiggavik mill. Mined out pits at the Kiggavik mine site will sequentially be used as tailings management facilities (TMFs), with East Zone being the initial TMF. The uranium product will be packaged and transported via aircraft to southern transportation networks. Initially, mill reagents, fuel and other supplies will be transported by barge to Baker Lake and then by truck to the mine site over a winter access road. An all-season road between Baker Lake and the Kiggavik site is carried as a secondary option proposed as a contingency in case the winter road cannot adequately support the Project over its lifespan.

Decommissioning of the Project will include demolition of site facilities, clean up and reclamation of any disturbed areas, closure of the TMFs and reclamation of mine rock piles to promote vegetative growth and to provide wildlife access.

Projection: NAD 1983 UTM Zone 14N
Creator: CDC
Date: 09/01/2011 Scale: 1:16,000,000
File:
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, Geological Survey of Canada, AREVA Resources Canada Inc.*

FIGURE 1.1-1
GENERAL LOCATION OF PROPOSED KIGGAVIK PROJECT IN CANADA

ENVIRONMENTAL IMPACT STATEMENT
TIER 2 VOLUME

Kiggavik Project

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

The Kiggavik Project is subject to the environmental review and related licensing and permitting processes established by the Nunavut Land Claims Agreement (NLCA), and to the licensing requirements of the Canadian Nuclear Safety Commission. The Minister of Indian and Northern Affairs Canada referred the Kiggavik Project to the Nunavut Impact Review Board (NIRB) for a Review under Part 5 of Article 12 of the NLCA in March of 2010. Pursuant to Section 12.5.2 of the NLCA:

"When a project proposal has been referred to NIRB by the Minister for review, NIRB shall, upon soliciting any advice it considers appropriate, issue guidelines to the Proponent for the preparation of an impact statement. It is the responsibility of the Proponent to prepare an impact statement in accordance with any guidelines issued by NIRB..." (NIRB 2011)

The final NIRB Guidelines for the Preparation of an environmental impact statement (EIS) for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011) were issued in May of 2011.

1.2 NUNAVUT IMPACT REVIEW BOARD GUIDELINES FOR THE ENVIRONMENTAL IMPACT STATEMENT

This volume is intended to address the following sections of the NIRB "Guidelines for the Preparation of an EIS for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011):

1. Section 8.1.4 – Terrestrial Environment
2. Section 8.1.11 – Vegetation
3. Section 8.1.12 – Terrestrial Wildlife and Habitat
4. Section 8.1.13 – Birds

The location of information related to each individual guideline is noted in the EIS Conformity Table (see Volume 1, Appendix 1).

1.3 PURPOSE AND SCOPE

The EIS has been prepared in fulfillment of the requirements of the NIRB Guidelines.

The purpose of this volume is to describe the Project components and activities that have the potential to interact with the terrestrial environment, and identify all potential environmental effects of the Project. The overall objective of the terrestrial environmental assessment is to provide sufficient detail on the Project to facilitate robust assessments of the potential effects of the Project on the biophysical and socio-economic environments.

The terrestrial environmental assessment focuses on the following environmental components:

- terrain
- soils
- vegetation
- wildlife and wildlife habitat

1.4 REPORT CONTENT

This volume is organized to focus on the key Project activities that have the potential to interact with the terrestrial environment that are recognized as a particular interest of regulatory agencies or the public. The terrestrial environment is broken down into four components: terrain, soils, vegetation, and wildlife.

This volume consists of the following sections:

Part 1 – Introduction and Methods

Section 1: A general introduction to AREVA, the Kiggavik Project, and the terrestrial environment assessment

Section 2: A description of the Kiggavik Project

Section 3: A description of the approach and methodology employed in the environmental assessment

Section 4: A list of references cited in Part 1

Part 2 – Terrain, Soils and Vegetation Assessments

Section 5: A description of the scope of the terrain, soils and vegetation assessments

Section 6: A brief description of the existing environment for terrain, soils, vegetation

Section 7: An assessment of the Project effects and cumulative effects on terrain

Section 8: An assessment of the Project effects and cumulative effects on soils

Section 9: An assessment of the Project effects and cumulative effects on vegetation

Section 10: A list of references cited in Part 2

Part 3 – Wildlife Assessment

Section 11: A description of the scope of the wildlife assessment

Section 12: A brief description of the existing environment for wildlife and wildlife habitat

Sections 13 through 16: An assessment of the Project effects and cumulative effects on the selected wildlife key indicators, specifically:

- ungulates
- raptors
- migratory birds
- species at risk

Section 17: A list of references cited in Part 3

Part 4 – Summary of Terrestrial Effects, Mitigation and Monitoring

Section 18: A summary of the overall Project effects and cumulative effects on the terrestrial environment

Section 19: A summary of the mitigation measures for the terrestrial environment

Section 20: A summary of the monitoring programs recommended for the terrestrial environment

Section 21: A list of references cited in Part 4

Tier 3 documents are appended to this volume to provide further details on the Project. These technical appendices are as follows:

- 6A – Surficial Geology, Terrain and Shallow Geotechnical Conditions
- 6B – Vegetation and Soils Baseline
- 6C – Wildlife Baseline
- 6D – Wildlife Mitigation and Monitoring Plan

2 PROJECT OVERVIEW

2.1 PROJECT FACT SHEET

Location	• Kivalliq Region of Nunavut, approximately 80 km west of Baker Lake. • The Project includes two mine sites: Kiggavik and Sissons (collectively called the Kiggavik Project). • The Kiggavik site is located at approximately 64°26'36.14"N and 97°38'16.27"W. • The Sissons site is located approximately 17 km southwest of Kiggavik at 64°20'17.61"N and 97°53'14.03"W. • The Kiggavik and Sissons sites are composed of 37 mineral leases, covering 45,639 acres.
Resources	• The total quantity of resources is currently estimated at approximately 51,000 tonnes uranium (133 million lbs U3O8) at an average grade of 0.46% uranium.
Life of Mine	• Approximately 12 years of operation, based on studies to date. It is anticipated that pre-operations construction will require 3 years while remaining post-operations decommissioning activities will require 5 years. • Under favourable market conditions, construction of the Project could begin as early as 2017.
Mining	• There are five individual mines proposed for the Project: East Zone, Center Zone and Main Zone at the Kiggavik site; End Grid and Andrew Lake at the Sissons site. • The three Kiggavik deposits and the Andrew Lake deposit will be mined by truck-shovel open pit, while End Grid will be an underground mine.
Mine Rock	• Mine rock will be segregated into material suitable for use in construction (Type 1), non-acid generating (Type II), and potentially problematic material (Type III). • Type II and Type III rock will be managed in surface stockpiles during operation. • Upon completion of mining, Type III mine rock will be backfilled into mined-out pits.
Mill	• The ore will be processed in a mill at the Kiggavik site to produce approximately 3,800 tonnes uranium (9.9 million lbs U3O8) per year as a uranium concentrate, commonly referred to as yellowcake.
Tailings	• The mill tailings will be managed at in-pit tailings management facilities constructed using the mined-out East Zone, Centre Zone and Main Zone open pits at the Kiggavik site. • Administrative and action levels will be used to control and optimize tailings preparation performance for key parameters.
Water Management	• A purpose-built-pit will be constructed at the Kiggavik site to optimize water management, storage, and recycling. • All mill effluent, tailings reclaim, and site drainage will be treated prior to discharge to meet the Metals Mining Effluent Regulations and site-specific derived effluent release targets. • Administrative and action levels will be used to control and optimize water treatment plant performance for key elements.
Site Infrastructure	• Power will be supplied by on-site diesel generators. • The operation will be fly-in/fly-out on a 7 to 14 day schedule with on-site employees housed in a permanent accommodations complex.

Access	• Access to the site will be provided by either a winter or all-season road between Baker Lake and Kiggavik. Supplies will be shipped to a dock facility at Baker Lake during the summer barge season and trucked to Kiggavik via the road. • An airstrip will be constructed and operated at site for transportation of personnel and yellowcake.
Environment	• Site-specific environmental studies have been on-going since 2007 • Public engagement and collection of Inuit Qaujimajatuqangit has been on-going since 2006; this information is integrated into the environmental effects assessment reports • AREVA's approach has been to integrate environmental assessment and decommissioning requirements into the Project design cycle to enhance mitigation of effects by design and to support the development of management, mitigation, and contingency plans to protect the environment
Benefits	• AREVA is negotiating an Inuit Impact Benefit Agreement with the Kivalliq Inuit Association • The total taxes and royalties to be paid on the Kiggavik Project would be approximately $1 billion, payable to Nunavut Tunngavik Inc., Government of Nunavut, and Government of Canada. • The Project is expected to employ up to 750 people during construction and 400 to 600 people during operation.

2.2 ASSESSMENT BASIS

The purpose of the assessment basis section is to define how the expected average design parameters detailed in the Project Description (Tier 2, Volume 2) have been bounded to ensure the effects assessments are adequately conservative.

The assessment basis is summarized in Table 2.2-1. For biophysical and some socio-economic effects, the range value with the greatest potential to result in an adverse effect is used. In the case of socio-economic benefits, the range value resulting in the lowest benefit is used.

Table 2.2-1 Project Assessment Basis

Project Activities	Parameter	Units	Parameter / Assumption Values	
			Base Case (PD)	Assessment Case
Overall	Production Rate	Tonnes U per year	3,200 – 3,800	3,200 - 4,000
	Mill Feed Rate	Kilotonnes per year	69 – 946	Senes max
	Project Operating Life	Years	14	25
	Project Footprint	ha	938	1,021
Milling	Flowsheet	N/A	No SX	SX Possibly calciner
	Final Product	N/A	Non-calcined	Calcined and non-calcined

Table 2.2-1 Project Assessment Basis (cont'd)

Project Activities	Parameter	Units	Parameter / Assumption Values	
			Base Case (PD)	Assessment Case
Tailings Management	Containment volume	Mm^3	28.4	30.0
	Total tailings volume (un-consolidated)	Mm3	21	30.0
	Design		Natural surround, no drain	Various design contingencies
Water Management	Freshwater requirements – no permeate or site drainage recycle	m^3/day	7,910	8,000
	Freshwater requirements – permeate and site drainage recycle	m^3/day	2,000	8,000
	Freshwater requirements - Sissons	m^3/day	500	600
	Treated effluent discharge at base quality – Kiggavik	m^3/day	2,707	3,000
	Treated effluent discharge – Sissons	m^3/day	1,700	1,700
Power Generation	Kiggavik peak load	MW	12.5	12.5 – 16.6
	Sissons peak load	MW	4.1	0 – 4.1
Logistics and Transportation	Number of barge trips – 5000t & 270 containers	Barge trips / year	9 - 31	31
	Number of barge trips – 7500t & 370 containers	Barge trips / year	7 - 22	22
	Number of truck trips – 50,000L & 48t	Truck trips / year	328 - 3233	3300
	Number of truck trips – 76,000L & 60t	Truck trips / year	243 - 2405	2500
	Number of yellowcake flights	Flights / year	310 - 350	355
	Road Route	N/A	Winter road S	Winter road S Winter road N All-season road N with cable ferry
	Dock location		Site 1	Sites 1, 2,3,4
Decommissioning	Period	Years	10	10

3 ASSESSMENT APPROACH AND METHODS

3.1 INTRODUCTION

This section describes the methods used in the assessment of environmental and socio-economic effects associated with the Kiggavik Project. The methods meet the applicable regulatory requirements while focusing the assessment on the matters of greatest environmental, social, cultural, economic and scientific importance. The methodological approach also recognizes the iterative nature of project-level environmental assessment, considering the integration of engineering design and mitigation and monitoring programs into comprehensive environmental management planning for the life of the Project.

The environmental effects assessment method is based on a structured approach that:

- considers the factors that are required under Nunavut Land Claim Agreement
- focuses on issues of greatest concern
- affords consideration of all territorial and federal regulatory requirements for the assessment of environmental effects
- considers issues raised by the Inuit, regulators, government agencies and public stakeholders
- integrates Project design and programs for mitigation and monitoring into a comprehensive environmental planning

The environmental assessment focuses on specific environmental components called Valued Environmental Components (VECs) or Valued Socio-economic Components (VSECs) that are of particular value or interest to Inuit, regulators, government agencies and stakeholders. The term Valued Components (VCs) refers collectively to VECs and VSECs. Valued Components are selected based on regulatory issues and guidelines, consultation with Inuit, regulators, government agencies and stakeholders, field studies, and professional judgment of the study team. Where a VC has various sub-components that may interact in different manners with the Project, the environmental assessment may consider the environmental effects on individual Key Indicators (KIs).

The term “environmental effect” is used throughout the Application and broadly refers to the response of the biophysical or human system or a component of these systems to a disturbance from a Project action or activity or other regional actions (i.e., projects and activities).

The environmental assessment methods address Project-related and cumulative environmental effects. Project-related environmental effects are changes to the biophysical or socio-economic environment that are caused by the Project or activity arising solely because of the proposed principal works and activities, as defined by the Scope of the Project. This includes consideration of the environmental effects of malfunctions or accidents that may occur in connection with the Project. Cumulative environmental effects are changes to the biophysical or socio-economic environment that are caused by an action of the Project in combination with other past, present and future projects and activities.

In this assessment, Project-related environmental effects and cumulative environmental effects are assessed sequentially. The mechanisms through which a Project-specific environmental effect may occur are discussed first, taking into account Project design measures and mitigation that help to reduce or avoid environmental effects. The residual environmental effect is then characterized taking into account planned mitigation. At a minimum, all Project environmental effects are characterized using specific criteria (e.g., magnitude, geographic extent, duration) that are defined for each VC.

A cumulative environmental effects screening is then conducted to determine if there is potential for the Project residual environmental effect to act in a cumulative manner with similar environmental effects from other projects and activities. If there is potential for the Kiggavik Project to contribute to cumulative environmental effects, the environmental effect is assessed to determine if it has the potential to shift a component of the natural or socio-economic environment to an unacceptable state.

The environmental effects assessment approach used in this assessment involves the following steps:

- ***Scoping***: Scoping of the overall assessment, which includes: issues identification; selection of VCs (and KIs, if required); description of measurable parameters; description of temporal, spatial, administrative and technical boundaries; definition of the parameters that will be used to characterize the Project-related environmental effects and cumulative environmental effects; and identification of the standards or thresholds that will be used to determine the significance of environmental effects.
- ***Assessment of Project-related environmental effects***: The assessment of Project-related environmental effects, which includes: description of the mechanism(s) by which an environmental effect will occur; mitigation and environmental protection measures to reduce the environmental effect; and evaluation and characterization of the residual environmental effects (i.e., environmental effects remaining after application of mitigation measures) of the Project on the biophysical and socio-economic environment for each development phase.

- ***Evaluation of cumulative environmental effects:*** The evaluation of cumulative environmental effects, which involves two tasks: screening for potential cumulative environmental effects and, if there is potential for cumulative environmental effects, assessment of cumulative environmental effects. Where an assessment of potential cumulative environmental effects is required, the residual cumulative environmental effects of the Project are evaluated in combination with other past, present and future projects and activities.
- ***Determination of significance***: The significance of Project-related and cumulative residual environmental effects is determined using standards or thresholds that are defined for each VC.
- ***Monitoring***: Several different types of monitoring may be required to confirm compliance with mitigation measures or Project design features, address uncertainties or verify environmental effects predictions and/or assess the effectiveness of mitigation measures.
- ***Summary***: The last step of the assessment of environmental effects on a VC is the development of summaries on Project and cumulative environmental effects (including combined Project environmental effects and combined cumulative environmental effects), mitigation measures and Project design features, and monitoring.

3.2 SCOPE OF THE ASSESSMENT

3.2.1 Valued Components, Indicators and Measurable Parameters

Valued Components (VCs) are defined as broad components of the biophysical and socio-economic environments, which if altered by the Project, would be of concern to regulators, Inuit, resource managers, scientists, and public stakeholders.

Valued Environmental Components (VECs) for the biophysical environment typically represent major components or aspects of the physical and biological environment that might be altered by the Project, and are widely recognized as important for ecological reasons.

Criteria for selection of VCs include:

- Do they represent a broad environmental, ecological or human environment component that may be altered by the Project?
- Are they vulnerable to the environmental effects of the Project and other activities in the region?

- Have they been identified as important issues of concerns of Inuit or stakeholders, or in other assessments in the region?
- Were they identified by the NIRB, Inuit organizations or departments within the territorial or federal government?

Key indicators (KIs) are species, species groups, resources or ecosystem functions that represent components of the broader VCs. They are selected using the same criteria as described above for VECs. For practical reasons, KIs are often selected where sufficient information is available to assess the potential Project residual environmental effects and cumulative environmental effects.

For each VC or KI, one or more measurable parameters are selected to measure quantitatively or qualitatively the Project environmental effects and cumulative environmental effects. Measurable parameters provide the means of determining the level or amount of change to a VC or KI. The degree of change in the measurable parameter is used to characterize project-related and cumulative environmental effects, and evaluate the significance of these effects. Thresholds or standards are identified for each measurable parameter, where possible, to assist in determining significance of the residual environmental effect.

3.2.2 Key Issues

Issues identification focuses the assessment on matters of greatest importance related to the Project, and assists in determining which factors and the scope of those factors that will be considered in the assessment.

Issues and concern about the possible biophysical or socio-economic effects of the Project have been identified from a variety of sources, including:

- the regulatory requirements applicable to the Project
- discussions with technical experts from various territorial and federal government agencies
- input from Inuit and public stakeholders during engagement activities in relation to the Project
- existing regional information and documentation regarding environmental components found near the Project
- baseline and assessment studies conducted in the area of the Project
- professional judgment of the assessment team, based on experience with similar projects elsewhere and other mining project and activities in Nunavut

Key Project-related issues are summarized in the scoping section for each discipline considered in the assessment.

3.2.3 Project-Environment Interactions and Environmental Effects

Key Project-related activities that are likely to result in environmental effects are considered for each VC. A matrix of Project activities and environmental components is provided in the scoping section for each discipline to identify where interactions are likely to occur based on the spatial and temporal overlap between Project activities and the VC. Each interaction is ranked according to the potential for an activity to cause an environmental effect. The interactions are ranked according to the following:

- If there is no interaction or no potential for substantive interaction between a Project activity and the VC to cause a potential environmental effect, an assessment of that environmental effect is not required. These interactions are categorized as 0, and are not considered further in the EA. The environmental effects of these activities are thus, by definition, rated not significant.
- If there is likely to be a potential interaction between a Project activity and a VC but not likely to be substantive in light of planned mitigation, the interaction is categorized as 1. Such interactions are well understood and are subject to prescribed mitigation or codified practices. These interactions are subject to a less detailed environmental effects assessment and are rated as not significant. Justification is provided and the mitigation is described for such categorizations. Such interactions can be mitigated with a high degree of certainty with proven technology and practices.
- If a potential interaction between a Project activity and a VC could result in more substantive environmental effects despite the planned mitigation, if there is less certainty regarding the effectiveness of mitigation, or if there is high concern from regulatory agencies, Inuit or stakeholders, the interaction is categorized as 2. These potential interactions are subject to a more detailed analysis and consideration in the environmental assessment in order to predict, mitigate and evaluate the potential environmental effects.

The ranking takes a precautionary approach, whereby interactions with a meaningful degree of uncertainty are assigned a rank of 2 to ensure that a detailed analysis of the potential environmental effect is undertaken.

Justification for ranking the Project-environmental interactions considered for each VC is provided in the scoping section for each discipline.

3.2.4 Assessment Boundaries

Boundaries of the assessment are defined for each VEC to allow for a meaningful analysis of the significance of environmental effects. The assessment boundaries are described in terms of temporal, spatial and administrative and technical boundaries.

3.2.4.1 Spatial Boundaries

Spatial boundaries are established for assessing the potential Project-related environmental effects and cumulative environmental effects on each VC. The primary consideration in establishing these boundaries is the probable geographical extent of the environmental effects (i.e., the zone of influence) on the VC.

Spatial boundaries represent the geographic extent of the VC, as they pertain to potential Project-environment interactions. Spatial boundaries are selected for each VC to reflect the geographic extent over which Project activities will or are likely to occur, and as such, they may be different from one VEC to another depending on the characteristics of the VC. For this assessment, the spatial boundaries are referred to as 'assessment areas' to differentiate the areas from the local and regional study areas referred to in many baseline studies.

Three assessment areas are defined for each VC.

The ***Project Footprint*** is the most immediate area of the Project. The Project Footprint includes the area of direct physical disturbance associated with the construction or operation of the Project.

The ***Local Assessment Area*** (LAA) is the maximum area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. The LAA includes the Project Footprint and any adjacent areas where Project-related environmental effects may be reasonably expected to occur.

The ***Regional Assessment Area*** (RAA) is a broader area within which cumulative environmental effects on the VC may potentially occur. This will depend on physical and biological conditions (e.g., air sheds, watersheds, seasonal range of movements, population unit), and the type and location of other past, present or reasonably foreseeable projects or activities. For the socio-economic environment, the RAA may be much broader (planning areas, regions, territories etc.) based on the potential geographic extent over which socio-economic effects are likely to occur. It is also the area where, depending on conditions (e.g., seasonal conditions, habitat use, more intermittent and dispersed Project activities), Project environmental effects may be more wide reaching.

3.2.4.2 Temporal Boundaries

The temporal boundaries for the assessment are defined based on the timing and duration of Project activities and the nature of the interactions with each VC. Temporal boundaries encompass those periods during which the VCs and KIs are likely to be affected by Project activities.

For the Kiggavik Project, temporal boundaries include the following Project phases.

- construction
- operation
- final closure
- post-closure

The operation phase includes consideration of maintenance, planned exploration and temporary closure (care and maintenance) of the Project. The final closure phase considers decommissioning and reclamation, and post closure phase includes management of restored sites.

In some cases, temporal boundaries are refined to a specific period of time beyond simply limiting them to a specific phase of the Project. This is carried out as necessary within each environmental effects analysis section. Temporal boundaries for the assessment may reflect seasonal variations or life cycle requirements of biological VCs, long-term population cycles for some biological VECs, or forecasted trends for socio-economic VSECs.

3.2.4.3 Administrative and Technical Boundaries

Administrative and technical boundaries are identified and justified for each VC or KI, as appropriate. Administrative boundaries include specific aspects of provincial, territorial and federal regulatory requirements, standards, objectives, or guidelines, as well as regional planning initiatives that are relevant to the assessment of the Project's environmental effects on the VC. Administrative boundaries may be selected to establish spatial boundaries.

Technical boundaries reflect technical limitations in evaluating potential environmental effects of the Project, and may include limitations in scientific and social information, data analyses, and data interpretation.

3.2.5 Environmental Effects Criteria

Where possible, the following characteristics are described quantitatively for each VC to assist in the assessment of residual environmental effects. Where these residual environmental effects cannot be defined quantitatively, they are described using qualitative terms. If qualitative descriptions are used, definitions are provided for each VC or KI, as appropriate, in the scoping section of the environmental assessment for that VC or KI.

- ***Direction:*** the ultimate long-term trend of the environmental effect (e.g., positive, neutral or adverse)
- ***Magnitude:*** the amount of change in a measurable parameter or variable relative to the baseline case (i.e., low, moderate, high)
- ***Geographical Extent:*** the geographic area within which an environmental effect of a defined magnitude occurs (site specific, local, regional, territorial, national, international)
- ***Frequency:*** the number of times during the Project or a specific Project phase that an environmental effect may occur (i.e., once, sporadically, regular, continuous)
- ***Duration:*** this is typically defined in terms of the period of time that is required until the VC returns to its baseline condition or the environmental effect can no longer be measured or otherwise perceived (i.e., short term, medium term, long term, permanent)
- ***Reversibility:*** the likelihood that a measurable parameter for the VC will recover from an environmental effect (i.e., reversible, irreversible)
- ***Ecological or socio-economic context:*** the general characteristics of the area in which the Kiggavik Project is located (i.e., undisturbed, disturbed, urban setting)

3.2.6 Standards or Thresholds for Determining Significance

Where possible, threshold criteria or standards for determining the significance of environmental effects are defined for each VC or KI to represent that limit beyond which a residual environmental effect would be considered significant. In some cases, standards or thresholds are also defined for specific environmental effects on a VC or KI.

Standards are recognized federal and territorial regulatory requirements or industry objectives that are applicable to the VC, and that reflect the limits of an acceptable state for that component. Where standards, guidelines or regulatory requirements do not specifically exist, thresholds are defined for the measurable parameters for an environmental effect on a VC based on resource management objectives, community standards, scientific literature, or ecological processes (e.g., desired states for fish or wildlife habitats or populations).

Potential changes in a measurable parameter or VC resulting from residual Project or cumulative environmental effects are evaluated against these standards or thresholds. Environmental effects are rated as either *significant* or *not significant*.

3.2.7 Influence of Engagement on the Assessment

Engagement undertaken to date with regulators, Inuit and public stakeholders in relation to the Project is described in Volume 3. Issues raised during these engagement activities and Inuit Qaujimajatuqangit (IQ) sessions were documented, and were reviewed for consideration in each discipline-specific assessment, including scoping of baseline data collection, selection of VC and KIs, use of TEK and IQ in the environmental effects assessment, mitigation and monitoring.

3.3 ASSESSMENT OF PROJECT ENVIRONMENTAL EFFECTS

3.3.1 Existing Conditions

The existing conditions for each VC are described according to the status and characteristics of the VC within its defined spatial and temporal assessment boundaries. This is based on a variety of sources, including:

- information from past research conducted in the region
- Inuit Qaujimajatuqangit
- knowledge gained from the collection of baseline data through literature review, qualitative and quantitative analyses, and field programs carried out as part of the environmental assessment

In general, the description of existing conditions is limited to information directly relevant to the potential VC interactions with the Project to support the environmental effects analysis.

3.3.2 Project Effect Linkages

The mechanisms or linkages through which the Project components and activities could result in an environmental effect on a VC, and the spatial and temporal extent of this interaction is described based on the existing conditions of the VC. Because the assessment focuses on residual environmental effects, effects prior to mitigation are not characterized or quantified and the significance of the effect is not determined.

3.3.3 Mitigation Measures and Project Design

Where Project activities are likely to cause an environmental effect on a VC, mitigation measures are identified to minimize or avoid environmental effects of the Project. This includes measures or strategies that are technically and economically feasible and that would reduce the extent, duration or magnitude of the environmental effect.

Mitigation includes Project design features to change the spatial or temporal aspect of the Project, specialized mitigation, environmental protection measures and protocols, and compensation (habitat compensation, replacement or financial compensation).

Where mitigation is identified, a brief discussion of how the measure(s) will help to minimize the residual environmental effect on the VC is provided. Where possible, this includes a description of how effective the measure is expected to be in minimizing the change in the measurable parameters for the environmental effect.

3.3.4 Project Residual Environmental Effects Assessment

Taking into account the mitigation and expected effectiveness of the measure(s), the residual environmental effects of the Project are described according to their probable magnitude, geographic scope, duration, frequency, reversibility and ecological context, where appropriate. The residual effect is characterized in the context of the existing condition for the measureable parameter(s) and how it is likely to change. For some residual environmental effects, the change in the measurable parameter is described relative to each Project phase.

Where possible, the magnitude, geographic extent and duration of the residual environmental effect are quantified. If a residual effect cannot be quantified, qualitative terms are used to describe the attributes of the effect.

3.3.5 Significance of Project Residual Environmental Effects

Significance of a Project residual environmental effect is determined based on standards or thresholds that are specific to the VEC, KI or the measurable parameters used to assess the environmental effect. Determination of whether a residual environmental effect is not significant is based on a comparison of the predicted change in the VC or measurable parameter to the defined threshold or standard. This includes an indication of the likelihood that a residual environmental effect on a VC will occur based on probability of occurrence (i.e., based on past experience) and level of scientific uncertainty.

Determination of significance also includes a discussion of the confidence of the prediction with respect to:

- the characterization of environmental effects
- the success of Project design features, mitigation measures, and environmental protection measures in effectively reducing the environmental effect

Prediction confidence for the environmental effect and the success of mitigation measures is ranked as low, moderate or high.

3.3.6 Monitoring of Project Residual Environmental Effects

Based on analysis of the residual Project environmental effect, it may be necessary to conduct a monitoring program. Monitoring is recommended in cases where there is a need to address Project-related issues of public concern, test the accuracy of the assessment predictions, verify the success of the mitigation measures, or gain additional scientific knowledge related to prediction of the Project environmental effect.

Two types of monitoring are considered: compliance and follow-up environmental monitoring.

Compliance monitoring is undertaken to confirm that Project design features, mitigation measures, environmental protection measures, or benefit agreements are being effectively implemented.

Biophysical and socio-economic monitoring programs are used to:

- verify predictions of environmental effects
- determine the effectiveness of mitigation measures, environmental protection measures or benefits agreements in order to modify or implement new measures where required
- support the implementation of management measures to address previously unanticipated adverse environmental effects
- support environmental management systems used to manage the environmental effects of projects

Where a monitoring program for a specific VC or KI is identified, the following aspects of the program are defined:

- parameters to be measured
- methods and equipment to be used

- location and timing of surveys
- how the results of the monitoring will be applied, including consideration of an adaptive management approach

3.4 ASSESSMENT OF CUMULATIVE ENVIRONMENTAL EFFECTS

3.4.1 Screening for Potential Cumulative Effects

Cumulative environmental effects are only assessed if the following criteria are met for the residual Project effect under consideration:

- The Project will result in a measurable, demonstrable or reasonably expected residual environmental effect on a component of the biophysical or socio-economic environment.
- The Project-specific residual environmental effect on the component will likely act in a cumulative fashion with the environmental effects of other past or future projects or activities that are likely to occur (i.e., Is there overlap of environmental effects?).
- There is a reasonable expectation that the Project's contribution to cumulative environmental effects will be substantive, measurable or discernible such as that it will affect the viability or sustainability of the resource.

If, based on these criteria, there is potential for cumulative environmental effects, the effect is assessed further to determine if it is likely to shift the component to an unacceptable state. Where there is no potential for the environmental effect of the Project to spatially or temporally overlap with similar effects of other project and activities, justification for not carrying these environmental effects forward to the assessment of cumulative environmental effects is provided.

3.4.2 Project Inclusion List

The Project inclusion list includes all past, present and reasonable foreseeable projects, activities and actions in the region of the Kiggavik Project. Only projects and activities that overlap with the Project residual environmental effects both spatially and temporally are considered in the assessment of potential cumulative environmental effects.

The specific projects, activities and action considered for each environmental effect are described in the assessment for the VC or KI.

3.4.3 Description of Cumulative Environmental Effects

The first step in the assessment of cumulative environmental effects involves describing the environmental effect, the mechanisms by which the Project environmental effect may interact cumulatively with other projects and activities in the RAA (from the Project Inclusion List), and the geographic and temporal scope of the cumulative environmental effect.

For this assessment, cumulative environmental effects are described for four cases. A more detailed description of the assessment cases is provided within the Project Inclusion List (Volume 1, Appendix 1B).

- ***Base Case***: the status of the measurable parameters for the environmental effects at baseline (i.e., prior to the Project). Baseline includes all past and present projects and activities in the RAA that may result in similar environmental effects to the Project environmental effect, including ongoing mineral exploration. Existing projects include projects that have received environmental approval and are in some form of planning, construction or commissioning.
- ***Project Case***: the status of the measurable parameters for the environmental effect with the Project in place, over and above the Base Case. This is usually assessed using the peak environmental effect of the Project or maximum active footprint for the Project.
- ***Future Case***: the status of the measurable parameters for the environmental effect because of the Project Case, in combination with all reasonable foreseeable projects, activities and actions. Reasonably foreseeable projects are defined as future projects, activities and actions that will occur with certainty, including projects that are in some form of regulatory approval or have made a public announcement to seek regulatory approval.

  For this assessment, future projects include proposed mines that are currently under NIRB review:

  - Meadowbank
  - Doris North 1
  - Doris North 2
  - Meliadine
  - Mary River
  - Hackett River
  - Back River

- Hackett River
- High Lake

The combination of the Project Case with the Future Case allows determination of the Project's contribution to cumulative effects of all past, present and reasonably-foreseeable projects and activities.

- ***Far Future Case:*** the status of the measurable parameters for the environmental effect because of the Future Case, in combination with possible far future developments in the Kiggavik region.

  It is recognized that exploration activities will continue near the Kiggavik Project, and that there is the potential for additional resources to be discovered during the life of the Project. To address such a possibility, a potential far future development scenario is defined in Table 3.4-1.

Table 3.4-1 Far Future Case Scenario Definition

Component	Locations
Uranium mines	three mines within 200 km of Kiggavik
Uranium mills	Kiggavik mill
Gold mines	1 mine within Kiggavik RAA Meadowbank region
Gold mills	Meadowbank region Additional mill within Kiggavik RAA
Access Roads	Meadowbank region Additional mill within Kiggavik RAA
Exploration	Induced exploration near the access road(s) and in the Kiggavik area

Due to the lack of information regarding the specific details of potential future developments (i.e., footprint of projects and activities), the assessment of cumulative environmental effects under this case is qualitative and is limited to a description of how these projects, activities and actions could affect the magnitude, duration and extent of cumulative environmental effects.

3.4.4 Mitigation of Cumulative Environmental Effects

Mitigation measures that would reduce the Project's environmental effects are described for cumulative environmental effects, with emphasis on measures that should limit the interaction of environmental effects of the Project with similar environmental effects from other projects. Three types of mitigation measures are considered, where appropriate:

- measures that can be implemented solely by AREVA

- measures that can be implemented by AREVA, in cooperation with other project proponents, government, Aboriginal organizations or public stakeholders
- measures that can be implemented independently by other project proponents, government, Aboriginal Organizations and/or public stakeholders

For the latter two types of mitigation, the degree to which AREVA can or cannot influence the implementation of these measures is noted.

Mitigation measures that could assist in reducing potential cumulative environmental effects are identified for each environmental effect, including a discussion of how these measures may potentially modify the characteristics of an environmental effect.

3.4.5 Residual Cumulative Environmental Effects Assessment

Residual cumulative environmental effects are described, taking into account how the mitigation will change the environmental effect. Where possible, cumulative environmental effects are characterized quantitatively or qualitatively in terms of the direction, magnitude, duration, geographic extent, frequency and reversibility. This includes characterization of:

- the total residual cumulative environmental effects based on the Future Case (i.e., the environmental effects of all past, present and reasonably foreseeable project and activities), in combination with the environmental effects of the Project
- the contribution of the Project to the total residual cumulative effects (i.e., how much of the total residual cumulative effects can be attributed to the Project)

3.4.6 Significance of Residual Cumulative Environmental Effects

The significance of cumulative environmental effects is determined using standards or thresholds that are specific to the VC, KI and/or measurable parameters used to assess the Project environmental effect. Determinations of significance are made for:

- the significance of the total residual cumulative environmental effect
- the significance of the contribution of the Project to the total residual cumulative environmental effect

The determination of residual cumulative environmental effects includes a discussion of the confidence of the prediction based on scientific certainty relative to:

- quantifying or estimating the environmental effect (i.e., quality and/or quantity of data, understanding of the effects mechanisms)
- the effectiveness of the proposed mitigation measures

As for residual Project environmental effects, prediction confidence for the cumulative environmental effect and the success of mitigation measures is ranked as low, moderate or high.

3.4.7 Monitoring of Cumulative Environmental Effects

Based on the evaluation of residual cumulative environmental effects, it may be necessary to conduct monitoring programs. Monitoring programs are designed to:

- confirm the effectiveness of a broad range of approved mitigation techniques
- determine whether different or an increased level of mitigation is required to achieve the mitigation or reclamation goals
- identify and address any cumulative effects that occur but are not predicted

Two types of monitoring are considered:

- Compliance monitoring: to confirm that Project design features, mitigation measures, environmental protection measures, or benefit agreements are being effectively implemented
- Biophysical or socio-economic monitoring: to confirm the environmental effect prediction and/or effectiveness of a Project design feature, mitigation measure, environmental protection measure, or benefit agreement

3.5 SUMMARY OF RESIDUAL ENVIRONMENTAL EFFECTS

Residual Project and cumulative environmental effects are briefly summarized for each VC. This includes a discussion of the overall combined environmental effect of the Project on the VC and its significance, as well as a discussion of the overall combined effect of all cumulative effects on the VC and its significance. For biophysical VECs, this relates to the sustainability of the resource or populations being considered. For socio-economic VSECs, this relates to the ability of the community, the Kivalliq region or Nunavut to adapt to or manage the environmental effect. A discussion of the Project's contribution to the combined cumulative effect is also provided.

In addition, this summary section presents an assessment of the effects of climate change on residual Project and cumulative effects. Where possible, the effects are described quantitatively, and include a description of how likely climate changes in the region will likely influence Project and cumulative residual effects.

3.6 ASSESSMENT OF TRANSBOUNDARY EFFECTS

As required by the NIRB EIS guidelines, the assessment includes consideration of transboundary effects, where residual environmental effects are likely to extend beyond the Nunavut into federal waters and/or other provincial or territorial jurisdictions. As this is based largely on the cumulative effects assessment, the transboundary effects are characterized qualitatively or semi-quantitatively.

3.7 SUMMARY OF MITIGATION

A detailed description of the mitigation measures proposed to minimize or avoid project-related and cumulative effects on VCs is provided based on the scoping and effects analyses. This includes:

- relevant Project design features to reduce environmental effects
- Project policies (e.g., Inuit hiring policy)
- specialized mitigation measures to minimize environmental effects on VECs
- social or community programs to minimize environmental effects on VSECs
- environmental protection plans
- broader agreements (e.g., benefits agreements)
- compensation

3.8 SUMMARY OF MONITORING

Monitoring programs to address uncertainties associated with the environmental effects predictions and environmental design features and mitigation proposed for residual Project effects and cumulative effects are described in detail. This includes all compliance monitoring and environmental monitoring that may be applied during the life of the Project, and that will form the:

- Compliance Monitoring Program Framework
- Environmental Monitoring Program Framework
- Socio-Economic Monitoring Program Framework

- Post-Project Analysis Program Framework
- Follow-up Monitoring Programs

4 REFERENCES

CCME (Canadian Council of Ministers of the Environment). 2009. *Soil quality guidelines for the protection of environmental and human health.* Available at: http://st-ts.ccme.ca/. Accessed October 3, 2011.

NIRB (Nunavut Impact Review Board). 2011. *Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc's Kiggavik Project* (NIRB File No, 09MN003).

5 SCOPE OF ASSESSMENT FOR TERRAIN, SOILS AND VEGETATION

5.1 ISSUES AND CONCERNS IDENTIFIED DURING INUIT, GOVERNMENT AND STAKEHOLDER ENGAGEMENT

The NIRB EIS guidelines for the Kiggavik Project (the Project) (NIRB 2011) incorporated a number of issues and concerns identified during Inuit, government and stakeholder engagement related to Project effects on the terrestrial environment. These issues focused on the effect of the Project on landforms and terrain features, as well as soil quantity and quality (Section 8.1.4). Issues also included Project effects on vegetation abundance and diversity, vegetation quality, and the potential for invasive vegetative species (Section 8.1.11). Specific issues related to routine Project components and activities include:

- the effects on landforms during Project construction and operation
- soil erosion from surface disturbances
- soil quality from compaction, air emissions and dust deposition
- changes to radiation levels to the surrounding environment
- dewatering of the Andrew Lake Pit
- effects on vegetation abundance and diversity
- effects on vegetation quality from air emissions and dust deposition
- effects of the potential introduction of invasive or exotic species from Project equipment, vehicles, aircraft, and marine vessels

Workshops and other engagement sessions occurred in 2009 and 2010 to inform stakeholders of the Project, as well as to gather their feedback regarding issues and concerns. During the community information sessions in 2009, 3% of the participant's responses were related to concerns regarding terrain, soils, and vegetation. During the open house sessions in 2010, stakeholders identified how various environmental attributes were valued. Input received from the 2010 open house sessions showed that participants valued landforms for cultural importance (i.e., respect, pride) and aesthetics (i.e., beautiful, peaceful). Soils were of value for IQ and cultural importance (i.e., respect), berries were valued as a food source, and lichen was important for survival and traditional ways. A summary of the comments made during the engagement sessions is presented below.

Berries

Comments were made about the importance of berries for human consumption. Representative comments regarding berries were:

- "Lots of people in the region come to Chesterfield in August to pick berries" (CH OH 2010).
- Elders said that there are no special places for collecting plants, they did acknowledge that the area around Judge Sissons Lake was good for harvesting red berries and that plants were found everywhere (BLE 2009).
- "People use cloudberries and other plants for teas" (RIHT 2009).
- "Crowberries, blueberries, blackberries, and 'red' berries are harvested for food" (BLE 2009).

Dust

Specific concerns were expressed by participants regarding dust. Representative comments regarding dust included:

- "If AREVA builds a road, there will be dust from the road in the summer time. This dust will collect on the grass on which the caribou feed, and may impact caribou health. This should be minimized" (BLHT 2011).
- "Wind travels from Baker Lake towards Rankin Inlet, and that any airborne contaminants, such as dust, would find their way to Rankin Inlet" (RIHT 2009).
- "There are concerns about air pollutants travelling by way of dust particles. As well, there are dangers associated with the dust to human health and wildlife" (RB NIRB 2010).

Participants in the stakeholder engagement sessions wanted to see effective dust control measures implemented to prevent dust-related effects on the environment.

Lichen

Lichen was identified as an important food source for caribou, which are a valued species for Inuit traditional and cultural ways. One of the comments made during the engagement sessions was "lichen would become contaminated from prevailing winds" (WC HTO 2011).

Soil

Concerns were raised on the Kiggavik Project Blog website about Project effects on soils. Specifically, concerns focused on potential contamination of soil and its effect on food sources. A specific comment was made that "all the animals we eat rely on good soil" (Kiggavik Project Blog 2009).

Landforms

A comment posted on the Kiggavik Project Blog website stated the importance of landforms for Inuit. Specifically, the comment was “landforms are very important because we use the land everyday” (Kiggavik Project Blog 2009).

Permafrost

During the stakeholder engagement sessions, concerns were expressed regarding the potential for Project-related mining activities to expose permafrost and for uranium to melt the permafrost layer.

5.2 INFLUENCE OF INUIT AND STAKEHOLDER ENGAGEMENT ON THE TERRAIN, SOILS AND VEGETATION ASSESSMENT

Issues identified during the stakeholder engagement sessions were incorporated into the terrestrial assessment. About 100 comments relating to vegetation and the land were received through the engagement process. Of these, many focussed on the potential effects on traditional use plants such as berries (13%), vegetation and animals from dust and uranium (12%), and reclamation and monitoring concerns (8%). A summary of how stakeholder concerns influenced the terrestrial assessment are presented below:

Berries

Berry-producing plants were identified as an important traditional food source. Efforts were made to identify the Ecological Land Classification (ELC) map units that contain berry-producing plants, and Project effects on these map units are addressed in Section 9. Project-related effects associated with berries and their potential effects on animals and humans is described in the Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A).

Dust

Air dispersion modelling was completed to predict the dispersal patterns of dust created at the mine sites. Mitigation measures for controlling dust, as well as environmental monitoring for effects of dust on soils and vegetation are identified in Sections 8.2.4 and Section 9.3.4, respectively.

Lichen

The effects of Project-related activities on lichen are discussed in Section 9, while potential effects on wildlife that consume lichen that are subsequently consumed by humans are discussed in the Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A).

Soil

Soil contamination is addressed as part of the assessment of Project effects on soil quality. Accidents and Malfunctions (Tier 2, Volume 10) also addresses possible contamination of soils from accidental spills.

Landforms

Landforms is identified as one of the key components in the terrain assessment. Project effects on landforms are addressed in Section 7 of this report.

5.3 INFLUENCE OF INUIT QAUJIMAJATUQANGIT ON THE TERRAIN, SOILS AND VEGETATION ASSESSMENT

Inuit Qaujimajatuqangit focused primarily on plant use and plant harvesting areas. Elders noted there are no special places to collect plants, and that plants containing berries are found everywhere; however, elders did acknowledge that the area around Judge Sissons Lake was good for harvesting red berries (BLE 2009). This information was integrated into the assessment of Project effects on berry-producing plants (Section 9).

5.4 REGULATORY SETTING

5.4.1 Terrain

Although there are no federal or territorial guidelines and regulations that are applicable to assess the effect of changes in terrain, precedence for the inclusion of terrain as a valued environmental component (VEC) is found in a number of existing Environmental Assessment and Review Processes (EARPs) in the Arctic under the Canadian Environmental Assessment Agency (CEAA). Consequently, the terrain assessment is largely conducted qualitatively. However, a quantitative approach is adopted based on the previous experiences with similar projects in Nunavut and other parts of the Canadian Arctic and best professional judgment to determine the significance of the Project effects on terrain.

Some of existing EARPs in the Arctic were extracted from the CEAA website (CEAA 2009) including:

- Izok Lake EARP where sediments, geomorphology, and permafrost were included in the assessment
- Ekati Diamond Mine EARP where permafrost and eskers were brought forward
- Jericho Diamond Mine where project effects were considered for permafrost
- Doris North Project where landscape, terrain and regional geology were identified as VECs

5.4.2 Soils

5.4.3 Federal Policy on Wetland Conservation

The objective of the 1991 Federal Policy on Wetland Conservation is to "promote the conservation of Canada's wetlands to sustain their ecological and socio-economic functions, now and in the future" (Government of Canada 1991). One of the goals of this policy is a no net loss of wetland functions on federal lands and waters (Government of Canada 1991). Therefore, any loss of soils associated with wetlands is considered an effect, as soil is a critical component and indicator of wetland function (e.g., a change in soil type due to a change in site hydrology would indicate a change in wetland function). Environment Canada administers this policy. Part of the Project occurs in federal lands, where the policy is directly applicable.

5.4.4 Vegetation

5.4.4.1 Species at Risk Act

The *Species at Risk Act* (SARA) is a key federal government commitment to protect species from becoming extinct, providing legal protection to species at risk on federal lands. Environment Canada, Fisheries and Oceans Canada, as well as the Parks Canada Agency, depending on the area of responsibility, administer SARA. SARA aims to secure the actions necessary for the recovery of species identified as at risk. Species are assessed for designation as species at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and given protection through a jurisdictional commitment to action by the appropriate Minister. Schedule 1 of SARA is the official list of species at risk in Canada. Two vegetation species listed on Schedule 1 occur in Nunavut. These include a willow of Special Concern (Felt-leaf willow, *Salix silicicola*), and a moss with Threatened status (Porsild's Bryum, *Mielichhoferia macrocarpa*).

5.4.4.2 Nunavut Wildlife Act

The *Nunavut Wildlife Act* is territorial legislation under the NLCA. Its purpose is the management of wildlife and habitat in Nunavut, including the conservation, protection and recovery of species at risk. It provides legislative responsibility to implement the commitments of SARA on Nunavut lands. The *Nunavut Wildlife Act* is administered by Nunavut's Department of Environment.

5.4.4.3 Nunavut Land Claims Agreement Act

The *Nunavut Land Claims Agreement Act* is the 1993 agreement between the Inuit of the Nunavut Settlement Area and the Government of Canada that allowed for the creation of the territory and the Government of Nunavut (GN). The *Nunavut Land Claims Agreement Act* gave jurisdiction to the GN for wildlife management, land use planning, and natural resource management. The Nunavut Planning Commission (NPC) was established under this Act. The

NPC developed the Keewatin Regional Land Use Plan. The study areas for this Project occur within the Keewatin planning region.

5.4.4.4 Keewatin Regional Land Use Plan

The Keewatin Regional Land Use Plan was developed by the NPC. It has the objective that non-renewable resource development should have no significant effects on the environment, wildlife or wildlife habitat.

5.4.4.5 Federal Policy on Wetland Conservation

The objective of the Federal Policy on Wetland Conservation is to "promote the conservation of Canada's wetlands to sustain their ecological and socio-economic functions, now and in the future" (Government of Canada 1991). One of the goals of this policy is the no net loss of wetland function on federal lands and waters. Environment Canada administers this policy. Part of the Project occurs in federal lands, where the policy is directly applicable.

5.5 VALUED ENVIRONMENTAL COMPONENTS, INDICATORS AND MEASURABLE PARAMETERS

5.5.1 Valued Environmental Components

VECs are attributes that are of cultural or ecological importance that interact with the Project. VECs are selected based on criteria identified in the NIRB guidelines, scientific input, as well as concerns identified through public engagement. VECs selected for this assessment include terrain, soils and vegetation. Terrain was selected as a VEC because of its importance as a basic component of the terrestrial environment. Soil was selected as a VEC because they support ecosystems that provide biological and cultural values. Vegetation was selected as a VEC because of their contribution to biodiversity, their role as wildlife habitat, and their importance for traditional Inuit activities such as berry collection.

5.5.2 Indicators

Assessment indicators are often used to represent key aspects of the VEC that should be protected to maintain the continued health of the VEC and to protect its value for use by future generations of Nunavut residents and the public. For the terrestrial assessment, use of key indicators was not necessary for assessing Project effects on terrain, soils and vegetation.

5.5.3 Measurable Parameters

Measurable parameters refer to quantifiable and measurable aspects of the VEC or key indicator that are used to determine the magnitude and direction of environmental change associated with Project activities. Changes to the measurable parameters will be assessed to

determine the significance of Project activities on the VECs. Some environmental effects cannot be quantitatively predicted prior to the environmental effect occurring. As such, predictions based on knowledge and literature from research and monitoring projects can be made to qualitatively characterize the environmental effects. Measurable parameters used to assess environmental effects on terrain, soils and vegetation are discussed in Sections 7, 8 and 9, respectively.

5.6 PROJECT-ENVIRONMENT INTERACTIONS

Interactions will occur between Project activities and the terrestrial VECs during all phases (i.e., construction, operation, final closure, and post closure) of the Project. A detailed matrix showing potential interactions between all Project activities and the VECs is provided in Table 5.6-1.

The rationale for ranking Project interactions with the terrain, soils and vegetation VECs as 1 is presented below. All interactions ranked as 2 are carried forward into the effects assessment for each VEC.

Construct In-water/Shoreline Structures

Site preparation, excavation, contouring and construction of in-water and shoreline structures (i.e., Andrew Lake dewatering structure and dock site) could have potential effects to slope stability, shoreline erosion, slides, rock falls and slumping in surficial deposits and bedrock. These effects could also potentially induce changes in the permafrost regime and terrain instability. However, the following measures will be taken into consideration to mitigate these potential adverse effects during the construction phase of the Project.

- The key design criteria for the Andrew Lake dewatering structure will be based on the Canadian Dam Association Dam Safety Guidelines (CDA 2007), which considers the minimum factor of safety against slope stability failure for static and pseudostatic loading using the Earthquake Design Ground Motion (see Tier 3, Appendix 2F).
- Rockfill and till construction methods will be implemented. Till will be placed as trench backfill through the excavated rockfill under water in the excavation to act as a low hydraulic conductivity core of the structure. Selected crushed rockfills will be placed as a thermal cap over the till to promote consolidation of the till core and to reduce the thermal variation in the till zone.
- Slope stability analyses will further be taken as part of the detailed designed stage.

In the presence of above mitigation measures, the residual effects from in-water and shoreline construction activities on terrain are anticipated to be minor and hence the level of interaction between Project activities and the VEC is ranked as 1 and not carried forward for further assessment.

Table 5.6-1 Project-Environment Interactions: Terrain, Soils and Vegetation

Project Component	Project Activities	Terrain	Soils	Vegetation
Construction				
Economic Activities	Construction workforce management; contracts and taxes; advance training of operation workforce	0	0	0
In-Water Construction	Construct freshwater diversions and site drainage containment systems (dykes, berms, collection ponds)	2	2	2
	Construct in-water/shoreline structures	1	2	2
	Water transfers and discharge	1	0	0
	Freshwater withdrawal	0	0	0
On-Land Construction	Site clearing and pad construction (blasting, earth moving, loading, hauling, dumping, crushing)	2	2	2
	Road and airstrip construction	2	2	2
	Aggregate Sourcing	2	2	2
	Construct foundations	2	0	0
	Construct buildings	0	0	0
	Install equipment	0	0	0
	Install and commission fuel tanks	0	0	0
	Mill dry commissioning (water only)	0	0	0
Supporting Activities	Transport fuel and construction materials	0	2	2
	Air transport of personnel and supplies	0	0	1
	Hazardous materials storage and use	0	0	0
	Explosives storage and use	0	0	0
	Waste incineration and disposal	0	1	1
	Industrial machinery operation	0	2	2
	Power generation	0	2	2

Table 5.6-1 Project-Environment Interactions: Terrain, Soils and Vegetation (cont'd)

Project Component	Project Activities	Terrain	Soils	Vegetation
Operation				
Economic Activities	Workforce management; employment; contracts and taxes	0	0	0
Mining	Mining ore (blasting, loading, hauling)	2	2	2
	Ore stockpiling	1	2	2
	Mining special waste (blasting, loading, hauling)	2	2	2
	Special waste stockpiling	1	2	2
	Mining clean waste (blasting, loading, hauling)	2	2	2
	Clean rock stockpiling	1	2	2
	Mine dewatering	0	0	1
	Underground ventilation	0	0	2
	Backfill production and underground placement	0	0	0
Milling	Transfer ore to mill	0	2	2
	Crushing and grinding	0	2	2
	Leaching and U recovery	0	0	0
	U purification	0	0	0
	Yellowcake drying and packaging	0	0	0
	Tailings neutralization	0	0	0
	Reagents preparation and use	0	0	0
Tailings Management	Pumping and placement of tailings slurry	2	0	0
	Consolidation of tailings	0	0	0
	Pumping of Tailings Management Facility supernatant	0	0	0
Water Management	Create and maintain water levels	0	0	0
	Freshwater withdrawal	0	0	0
	Potable water treatment	0	0	0
	Collection of site and stockpile drainage	0	0	1

Table 5.6-1 Project-Environment Interactions: Terrain, Soils and Vegetation (cont'd)

Project Component	Project Activities	Terrain	Soils	Vegetation
Operation (cont'd)				
Water Management (cont'd)	Water and sewage treatment	0	0	0
	Discharge of treated effluents (including greywater)	0	0	0
Waste Management	Disposal of industrial waste	0	1	1
	Management of hazardous waste	0	1	1
	Management of radiologically contaminated waste	0	1	1
	Disposal of domestic waste	0	0	0
	Incineration and handling of burnables	0	1	1
	Disposal of sewage sludge	0	0	0
General Services	Generation of power	0	2	2
	Operate accommodations complex	0	0	0
	Recreational activities	0	1	1
	Maintain vehicles and equipment	0	0	0
	Maintain infrastructure	0	0	0
	Operate airstrip	0	1	1
	Hazardous materials storage and handling (reagents, fuel and hydrocarbons)	0	0	0
	Explosives storage and handling	0	0	0
Transportation	Marine transportation	0	0	0
	Truck transportation	0	2	2
	General traffic (Project-related)	0	1	1
	Controlled public traffic	0	1	1
	Air transportation of personnel, goods and supplies	0	1	1
	Air transportation of yellowcake	0	1	1
	General air transportation support	0	1	1

Table 5.6-1 Project-Environment Interactions: Terrain, Soils and Vegetation (cont'd)

Project Component	Project Activities	Terrain	Soils	Vegetation
Operation (cont'd)				
Ongoing exploration	Aerial surveys	0	1	1
	Ground surveys	0	0	0
	Drilling	1	1	1
Final Closure				
Economic Activities	Decommissioning workforce management; employment; contracts and taxes	0	0	0
General	Hazardous materials storage	0	1	1
	Industrial machinery operation	0	2	2
	Ongoing withdrawal, treatment and release of water, including domestic wastewater	0	0	0
In-water Decommissioning	Remove freshwater diversions; re-establish natural drainage	1	1	1
	Remove surface drainage containment	1	1	1
	Remove in-water/shoreline structures	0	1	1
	Water transfers and discharge	2	0	0
	Construct fish habitat as per the Fish Habitat Compensation Plan (FHCP)	0	0	1
On-land Decommissioning	Remove site pads (blasting, earth moving, loading, hauling, dumping)	2	2	2
	Backfilling	2	0	0
	Contouring	2	1	0
	Covering	1	1	0
	Revegetation	1	0	0

Table 5.6-1 Project-Environment Interactions: Terrain, Soils and Vegetation (cont'd)

Project Component	Project Activities	Terrain	Soils	Vegetation
Final Closure (cont'd)				
On-land Decommissioning (cont'd)	Remove foundations	1	0	0
	Remove buildings	0	0	0
	Remove equipment	0	0	0
	Remove fuel tanks	0	0	0
Post Closure				
General	Management of restored site	0	0	0

NOTES:

0 = If there is no interaction or no potential for substantive interaction between a Project activity and the VC to cause a potential environmental effect, an assessment of that environmental effect is not required. These interactions are categorized as 0, and are not considered further in the EA. The environmental effects of these activities are thus, by definition, rated not significant.

1 = If there is likely to be a potential interaction between a Project activity and a VC but not likely to be substantive in light of planned mitigation, the interaction is categorized as 1. Such interactions are well understood and are subject to prescribed mitigation or codified practices. These interactions are subject to a less detailed environmental effects assessment and are rated as not significant. Justification is provided and the proposed mitigation is described for such categorizations. Such interactions can be mitigated with a high degree of certainty with proven technology and practices.

2 = If a potential interaction between a Project activity and a VC could result in more substantive environmental effects despite the planned mitigation, if there is less certainty regarding the effectiveness of mitigation, or if there is high concern from regulatory agencies, Inuit or stakeholders, the interaction is categorized as 2. These potential interactions are subject to a more detailed analysis and consideration in the environmental assessment in order to predict, mitigate and evaluate the potential environmental effects

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Water Transfers and Discharge

There is potential for erosion within the constructed diversion channels, and the degree to which this occurs depends on the type of overburden material, channel gradient, channel geometry and flow magnitude. The potential for erosion is greatest where the excavation occurs in overburden till materials and it is much less where the excavation occurs in bedrock. As the channels are constructed in a permafrost environment, there is also potential for deformation in the constructed channel, which may influence erosion potential. The proposed channels will be constructed based on the available geotechnical data and information on shallow permafrost conditions, including thickness of the active layer. General mitigation measures by design for the channel alignments and construction in ice-poor and ice-rich till will be implemented, and the design and channel alignments may be further refined based on the additional information on ground conditions and material types (see Tier 3, Appendix 2E for details). Water transfer and discharge activities are anticipated to have a minor effect on terrain with implementation of the mitigation measures identified; therefore, the interaction was ranked as a 1, and was not carried forward for further assessment.

Ore, Special Waste, Clean Rock and Overburden Stockpiling

Development of ore stockpiles, special waste stockpiles, clean waste stockpiles and overburden stockpiles will result in a net increase in anthropogenic materials in the Mine LAA. In the Kiggavik mine site, approximately 7 ha, 13 ha, 135 ha and 14 ha will be disturbed by ore, special waste, clean waste and overburden stockpiles, respectively. This represents 169 ha (0.47%) of common landforms (till overburden materials) within the Mine LAA (36,240 ha) that will be disturbed due to the Project footprint of the Kiggavik mine. In the Sissons mine site, approximately 1 ha, 12 ha, 132 and 15 ha will be disturbed by ore, special waste, clean waste and overburden stockpiles, respectively. This represents 160 ha (0.44%) of common landforms (till overburden materials) within the Mine LAA that will be disturbed due to the Project footprint of the Sissons mine. A total of 329 ha (i.e., 0.91% of the total Mine LAA) of common landforms will be disturbed by the Project footprint due to the establishment of mine stockpiles within the Mine LAA, which is considered to be not significant. As overburden materials will be salvaged and used for the reclamation purpose, the residual effects from mine stockpiling on terrain are anticipated to be minor and hence the level of interaction is ranked as 1 and not carried forward for further assessment.

Air Emissions

A number of Project activities generate air emissions from fuel combustion; however, the amount of air emissions and their rate of occurrence vary. Project activities expected to generate small amounts or transient sources of air emissions that were subsequently ranked as 1 include air transport of personnel and supplies, operation of the airstrip, general traffic (Project-related), controlled public traffic, air transportation of personnel, goods, and supplies, air transportation of yellowcake, general air transportation support, aerial surveys, and drilling. However, truck transportation associated with ore haul traffic, as well as semi-trailer truck traffic from Baker Lake to the Kiggavik and Sissons mine sites along the proposed access roads are anticipated to produce large quantities of air emissions. As well, power generation, the acid

plant, operation of heavy equipment, and incineration of burnable refuse and wastes are anticipated to produce large quantities of air emissions, and will likely operate for extended periods of time during the operation phase of the Project. Therefore, these Project activities were ranked as 2 and carried forward into the effects assessment.

Mine Dewatering

Mine dewatering involves the removal of water that has seeped into an excavated area. During mine dewatering, the pumping of a well could influence groundwater flow. This has the potential to change groundwater levels, which in turn could affect vegetation that occurs within the cone of depression. However, the presence of continuous permafrost at the Kiggavik site likely acts as a barrier between groundwater and vegetation. As such, this interaction is ranked as 1 and is not discussed further in the assessment.

Collection of Site and Stockpile Drainage

Freshwater diversion channels will be created around the Project footprint area, as well as surrounding the rock stockpiles. Diversion channels created around the Project footprint will transport surface run-off around the site, where it will be released into the natural drainage system downslope of the Project footprint. Diversion channels around the rock stockpiles will transport surface run-off into a sedimentation pond located immediately adjacent to the rock stockpiles. The freshwater diversion channels will likely create new habitat for vegetation, allowing species adapted to mesic environments to establish and proliferate. The vegetation species anticipated to occur will likely be native to the area, as non-native species are likely unable to establish and proliferate due to the harsh climate conditions and nutrient deficient soils. As such, the diversion channels and sedimentation ponds are anticipated to have a minor effect on vegetation; thus, the interaction is ranked as 1 and not carried forward for further assessment.

Waste Management

Waste products (i.e., domestic, industrial, hazardous, radiological, and sewage) will be handled and disposed of in accordance with the GN's environmental guidelines. Recyclable materials will be collected and shipped to appropriate recycling facilities, non-combustible and non-contaminated wastes will be landfilled in a designated area of the clean waste rock piles, hazardous wastes will be collected in designated containers and transported to an appropriate off-site recycling or disposal facility, and radiological waste will be stored on-site for eventual burial in the Kiggavik Tailings Management Facility (TMF). Burnable wastes will likely be incinerated while meeting the GN (2011) environmental guidelines. A sewage treatment plant located on-site will meet Nunavut public health regulations and any requirements stipulated by the Nunavut Water Board and the Canadian Council of Ministers of the Environment (CCME) municipal effluent guidelines for sewage. Treated sewage effluent will be discharged into Judge Sissons Lake. The residual effects from these waste management practices on soils and vegetation are anticipated to be negligible. As such, this interaction is ranked as 1 and not carried forward for further assessment.

Recreational Activities

Recreational activities by people working at the mine could disturb soils and vegetation. For example, hiking at a specific location repeatedly can create a trail, thereby causing trampling and destruction of vegetation, as well as soils compaction. However, these types of activities will be localized. As such, the residual effects of recreational activities on soils and vegetation are anticipated to be negligible. The interaction is ranked as 1 and not carried forward for further assessment.

Drilling

Additional exploration drilling will occur over the life of the Project. Monitoring records from current exploration activities identified an area of approximately 8.5 m by 8.5 m (i.e., 72.25 m^2 or 0.007 ha) that may be disturbed by drilling activities. Drilling activities predominately occur from May to September during the spring thaw and snow-free periods on the landscape. Disturbances to terrain may include short-term and localized change in permafrost conditions and aesthetic visual intrusion in landforms within the drill rig set-up and its adjacent areas. Heat generated by generator, drilling and heating system may provisionally warm the active layer and deepening of thaw depth may occur. Changes to shallow permafrost conditions caused by drilling activities are known to recover to a previous disturbance state. Disturbances to soils include soil compaction where the drill rig is situated, minor scalping of the soil surface during drill placement and removal, as well as digging of a small pit (i.e., usually 0.5 m by 0.5 m) that is used to collect non-radioactive drill cuttings. Disturbance to vegetation at drill sites is predominately due to trampling. The majority of the soil growth medium, as well as the rooting structure of the vegetation remains intact at drilling sites, allowing for vegetation regeneration. Best management practices associated with drilling activities, the short duration during which a drill is at a particular location, and the small footprint associated with drilling activities will minimize any residual effects. The residual effects from drilling on soils and vegetation are anticipated to be negligible. As such, this interaction is ranked as 1 and not carried forward for further assessment.

In-water Decommissioning

Removal of the freshwater diversion channels, surface drainage containment systems, and in-water/shoreline structures during final closure of the Project will likely affect terrain, soils and vegetation. For terrain, a new shallow permafrost regime and terrain slope may be re-established at these locations. Shallow permafrost condition and the stability of terrain can likely be affected due to disturbances during final closure of the Project. To minimize the effects induced by decommissioning activities, compaction of materials will be allowed under gravity only. However, loose and unstable surficial materials will be reasonably removed in order to support the stability of adjacent terrain. Natural drainage and surficial materials will be re-established in such way that the residual effects on permafrost and terrain stability are expected to be mitigated and relatively unchanged, compared with the baseline condition.

Soil compaction may occur during structure removal, and vegetation that may have re-established at these locations could be lost due to decommissioning-related disturbances. To mitigate soil compaction during decommissioning activities, the disturbed area will be harrowed or scarified to loosen compacted soils. Decommissioning activities will promote re-establishment of native vegetation to these disturbed areas that is suitable for traditional uses. Therefore, the residual effects from in-water decommissioning activities on terrain, soils, and vegetation are anticipated to be beneficial at these locations; thus, the interaction is ranked as 1 and not carried forward for further assessment.

Contouring

Contouring of the waste rock piles to maintain slope stability may be required during the final closure phase. During this time, the area contoured by the heavy equipment will likely result in soil compaction, which could prevent vegetation establishment and proliferation. Harrowing during decommissioning activities will mitigate soil compaction issues while providing micro-sites for vegetation establishment and proliferation. As such, this interaction is ranked as 1 and not carried forward for further assessment.

Covering

Covering of the mine site footprints will occur during the final closure phase using stored overburden materials during reclamation. Covering is anticipated to occur at the mine pits (following completion of mine pit backfill) as well as the rest of the mine site footprint (excluding the waste rock piles and access roads). For the mine pits used as TMFs, the consolidated tailings materials will be backfilled with waste rock materials. Following placement of waste rock materials, two different scenarios exist for final covering of the pits: 1) the placement of overburden materials on top of waste rock; or 2) the development of a pond on top of the waste rock. Covering of the mine pits via either scenario will cause a change in terrain features prior to baseline conditions. However, covering of the mine pits will re-establish the natural shallow permafrost condition and promote terrain stability. For soils, soil compaction could potentially occur during the placement and spreading of soils over these pits. Harrowing during decommissioning activities will mitigate soil compaction issues while providing micro-sites for vegetation establishment and proliferation. As such, the residual effects that covering will have on terrain and soils are anticipated to be not significant; thus, the interaction is ranked as 1 and not carried forward for further assessment.

Revegetation

Revegetation of the mine pits and mine waste stockpiles will be required during final closure phase of the Project. After covering is placed at the mine pits (following completion of mine pit backfill) as well as the rest of the mine site footprint (excluding the waste rock piles and access roads), a top layer of the dry cover will then be revegetated to establish a vegetation medium. Revegetation will help re-establish the natural shallow permafrost condition and terrain stability. The residual effects that revegetation will have on terrain are anticipated to be not significant. Therefore, the level of interaction between revegetation and the VEC is ranked as 1 and not carried forward for further assessment.

Remove Foundations

Removal of the foundations during final closure of the Project will likely affect terrain. Compaction of backfill materials can occur during and after the removal of foundation structures and a new shallow permafrost regime and terrain condition may be re-established at these locations. To minimize the effects induced by decommissioning activities, compaction of materials will be allowed under gravity only. However, loose and unstable surficial materials will be reasonably removed in order to support the stability of adjacent terrain. Natural drainage and surficial materials will be re-established in such way that the residual effects on terrain are expected to be mitigated and relatively unchanged, compared with the baseline condition. Hence, the level of interaction between this Project activity and the VEC is ranked as 1 and not carried forward for further assessment.

5.7 ASSESSMENT BOUNDARIES

5.7.1 Project Footprint

The Project footprint is the area of direct physical disturbance by the Project, as described in the Project description. For the purposes of this assessment, the potential for variation in design and alignment of roads was taken into account by using a 12 m buffer on both sides of the proposed road centre line (24 m wide) for the North All-Season Road. The north and south winter roads incorporated a 6 m buffer on both sides of the proposed road centre line (12 m wide). The footprint of other mining facilities used the geographic limits provided by the Project's design team.

5.7.2 Local Assessment Area

The LAA is the maximum area within which Project effects can be predicted or measured with reasonable accuracy and confidence. The LAA was broken-down into two different areas consisting of the mine LAA and the road LAAs. The mine LAA is centered on the Kiggavik and Sissons deposits with an approximate 5 km buffer around all proposed Project facilities, including the proposed airstrip and access road between the Kiggavik and Sissons mine sites (Figure 5.7-1). The mine LAA for soils, vegetation, and wildlife is approximately 29 km by 20 km, for a total area of approximately 450.09 km^2 (45,009 ha). Information on surficial geology does not exist for the southwest portion of the mine LAA. As a result, the mine LAA boundary for terrain was adjusted to contain only the area where surficial geology information existed. The upland area within the mine LAA for terrain (excluding water) is 36,240 ha (Figure 5.7-1).

The road LAAs include a 5 km wide buffer centered on the proposed road alignments (Figure 5.7-1). The North All-Season Road LAA is approximately 520.32 km^2 (52,032 ha), whereas the North Winter Road LAA and South Winter Road LAA are approximately 539 km^2 (53,901 ha) and 560.9 km^2 (56,090 ha). The dock facility options are included within the North All-Season Road and South Winter Road LAA boundaries.

5.7.3 Regional Assessment Area

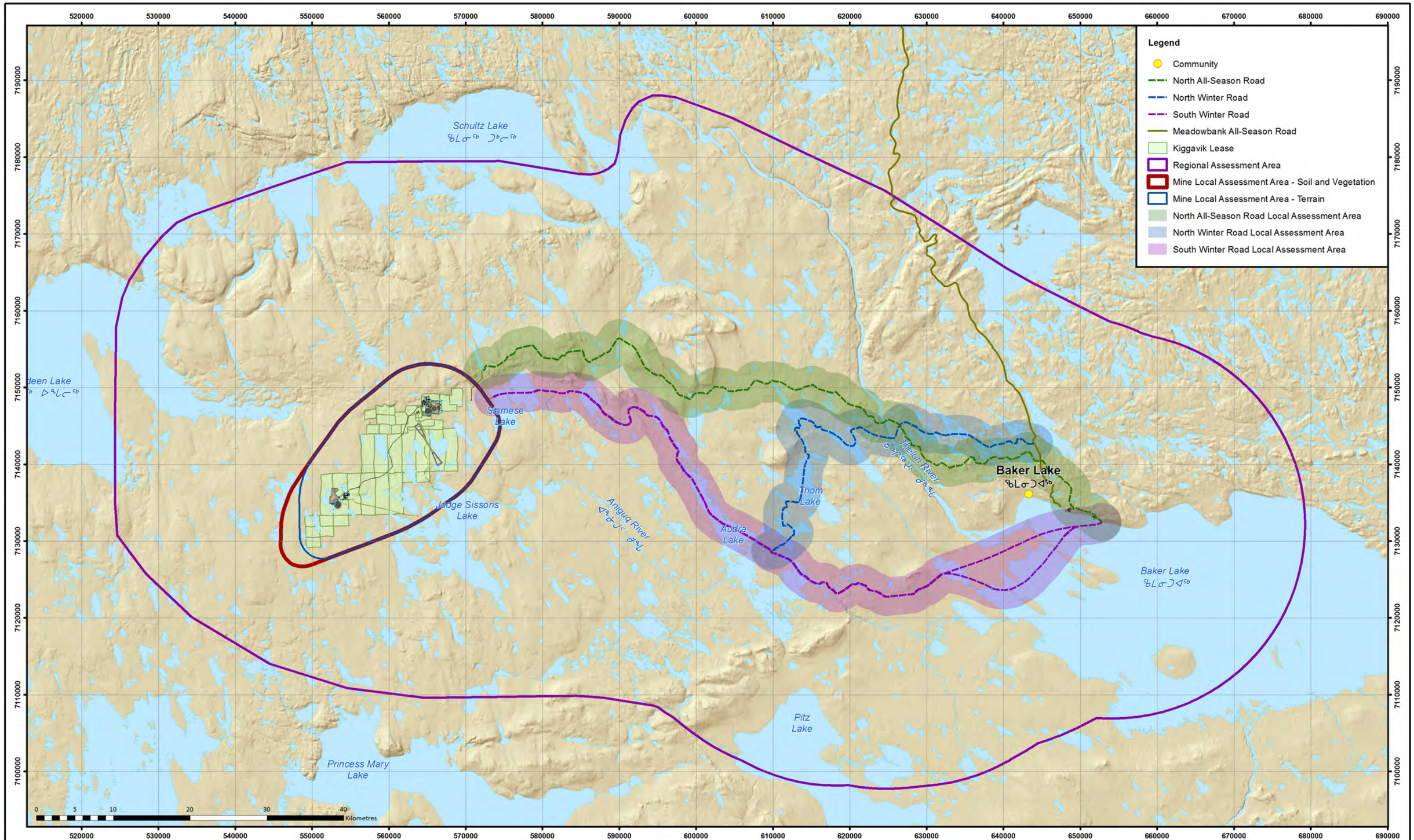
The regional assessment area (RAA) is a broader area within which cumulative effects may potentially occur, or a VEC is broader ranging. The RAA incorporates all Project features and associated LAA buffers, based on known caribou water crossing locations along the Thelon River basin (DIAND 1992), and critical areas identified by IQ studies (see Tier 3, Appendix 6C for further details). The RAA also includes areas with similar conditions to those found in the LAA and access road LAAs, which will allow the RAA to be used as a comparable reference area for monitoring potential changes as the Project proceeds. The RAA covers an area 150 km long and 70 km wide, for a total of 9,828 km^2 (982,800 ha; Figure 5.7-1). The RAA includes all of Judge Sissons Lake and southern portions of Aberdeen and Schultz lakes. The RAA has a minimum buffer of approximately 22 km from the Project footprint.

5.7.4 Temporal Boundaries

The temporal boundaries for the terrestrial assessments are based on the timing and duration of effects over all phases of the Project (construction, operation, final closure and post closure). The total life of the Project is expected to be 25 years (2017 to 2042).

5.8 RESIDUAL ENVIRONMENTAL EFFECTS CRITERIA FOR TERRAIN, SOILS AND VEGETATION

The NIRB has outlined specific terms to characterize residual environmental effects of the Project. Whenever possible, the magnitude, geographic extent, frequency and duration of an environmental effect were described quantitatively. Where quantitative measures were not available to describe the environmental effect, qualitative terms (e.g., low, moderate, and high) were used. Definitions specific to individual VECs are presented in the effects assessment sections for terrain, soils and vegetation.



Projection: NAD 1983 UTM Zone 14N
Creator: CDC
Date: 11/18/2011 Scale: 1:450,000
File:
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 5.7-1
LOCATION OF THE TERRAIN, SOILS AND VEGETATION LOCAL AND REGIONAL ASSESSMENT AREAS FOR THE KIGGAVIK PROJECT

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5.9 STANDARDS OR THRESHOLDS FOR DETERMINING SIGNIFICANCE

Under the NIRB Project-specific guidelines, the environmental assessment must include a determination of the significance of environmental effects. Threshold criteria or standards for determining the significance of environmental effects were identified for each VEC, beyond which a residual environmental effect would be considered significant. Where available, these were selected in consideration of federal and territorial regulatory requirements, standards, objectives, or guidelines applicable to the VEC.

Potential changes in a measurable parameter or VEC resulting from Project or cumulative effects were evaluated against these standards or thresholds, and were rated as either significant or not significant. Definitions specific to individual VECs are presented in the effects assessment sections for terrain, soils and vegetation.

6 SUMMARY OF EXISTING ENVIRONMENT TERRAIN, SOILS AND VEGETATION

6.1 TERRAIN

6.1.1 Introduction

This section summarizes surficial geology, terrain and shallow geotechnical conditions in the Kiggavik Project area. Additional details on the terrain baseline can be found in the Surficial Geology, Terrain and Shallow Geotechnical Conditions (Tier 3, Appendix 6A).

6.1.2 Surficial Geology

Surficial deposits consist mainly of glacial till and small local deltaic deposits. The glacial till varies in texture and composition from well-graded silty sand with some gravel and trace of clay to well-graded gravelly sand with some silt and a trace of clay. The till also contains boulders and cobbles, but only minor amounts of fine particles. The clay fraction of the glacial till exhibits little to no plasticity. Thin deposits of poorly graded sand and gravel, which occur locally on the till surface, are considered to have been produced by glacial melt-water and post-glacial erosion. Fields of large, angular boulders occur where the glacial till is relatively thin or absent, and also where the finer constituents of the till have been removed by erosion. Thin organic layers have been developed on the till surface in poorly drained depressions. Thin soil profiles have been developed on well-drained glacial till.

6.1.3 General Geomorphology

The periglacial geomorphic processes in the RAA are associated with the ground that is permanently affected by the cold climate, consisting of an active layer, excess ground-ice and a layer of perennially frozen ground. Periglacial processes observed within the mine LAA and RAA include frost wedging and frost shattering, thaw subsidence, and solifluction, which shaped various landforms. The characteristic relief-forming permafrost features are typically subdued in areas of thin overburden and dry conditions. Generally, wet conditions exist locally associated with low-lying ground.

The surficial deposits at the proposed mine site and along most of the potential road corridors between the mine/mill site and Baker Lake comprise mainly glacial till overlying Precambrian intrusive igneous and metamorphic rocks that are typically quartzite, schist or granite. The eastern portions of the potential road alignments toward Baker Lake are below the most recent

glacial marine transgression; consequently, the lower elevations near Baker Lake are partly covered by marine and glaciomarine materials.

6.1.4 Surficial Materials

A typical top layer of surficial material profile in the mine LAA consists of a thin organic soil layer underlain by glacial till varying in thickness from less than a metre on ridges to several meters in depressions, overlying moderately jointed bedrock with good rock quality. Large areas of boulders (boulder fields) exist on the ground surface where the finer fraction of the glacial till has been removed by erosion or where the boulders have been frost-jacked to surface by the repetitive freeze-thaw action of the active layer.

Surficial materials in the RAA originated as a result of glaciations by the Laurentide ice sheet, and marine offlap following its retreat (EBA 2010). These changes included:

- glacial deposition and erosion, which prevailed during expansion and subsequent retreat of the Laurentide ice sheet, including localized re-advances
- marine submergence, which occurred when much of the terrain near Baker Lake was temporarily inundated by an ancient sea (Tyrrel Sea)
- more recent periglacial conditions established when isostatic rebound of the earth's crust resulted in exposure of the land surface as the margin of the Hudson Bay retreated eastward

The surficial materials in the Project area have been historically grouped into six major deposits (BEAK Consultants Ltd. 1987; Wickware & Associates Inc. 1989): glacial till or morainal; glaciofluvial; glaciolacustrine; glaciomarine deposits; organic and bedrock.

Minor deposits of lacustrine materials occur in the Squiggly Lake area and along shorelines of larger lakes where ice-pushed sandy materials may occur. Their occurrence is of limited areal extent. Immediately to the east of these areas, the landscape is dominated by reworked marine deposits. These deposits mask bedrock and glacial deposits, and mute the lowland topography. The primary materials associated with this marine transgression are foreshore and beach deposits of sand and gravel. Such deposits are found on the flanks of hills and bedrock knobs, often with associated terraces marking the stages of the gradual recession of waters from the area (BEAK 1987). These deposits are characterized by a network of high centred ice-wedge polygons and by patterned peat deposits in the low poorly drained areas.

6.1.5 Landforms

The normal deposition and erosion processes associated with the various preglacial, glacial, marine, and the present day periglacial environments have resulted in the evolution of a variety of common landforms in the Project area. Major landforms are subdivided into four different types: depositional, glacial, permafrost sensitive and uncommon landforms.

6.1.5.1 Depositional Landforms

Common depositional landforms are further classified into six different types within the mine LAA as described below (Figure 6.1-1).

Undifferentiated Alluvium or Outwash Sediments

With the exception of the Kiggavik mine site and its north-northeast areas, undifferentiated alluvium or outwash sediments occur in all directions. However, these sediments occur in the Sissons mine site and adjacent areas. This type of landform covers 3,786 ha of the mine LAA, which represents 10.45% of this area.

Glaciofluvial

The material typically comprises unsorted and unstratified, moderately to well sorted and stratified gravel and sand. Ground-ice content in glaciofluvial deposits is typically low. Glaciofluvial outwash materials occur randomly throughout the mine LAA and are generally composed of granular soils. Percentage coverage of glacioflucial landform is less than 1% of the mine LAA, or 200 ha.

Glacial Till or Moraine

Till ground moraine is the most common and widespread depositional landform in the Kiggavik Project area. The till is generally unsorted, medium brown, silty, sandy and stony, with locally derived volcanic, sedimentary, and lesser granitic clasts. Clast sizes range from granule to boulder with a high proportion in the gravel-sized range. It consists mainly of till blanket, till veneer and hummocky till. The coarse-grained materials common in most of the channels between lakes and ponds are evidence of the finer sediments having been removed by water flow. This type of landform occupies most (approximately 83.76% or 30,356 ha) of the LAA.

Due to the fine texture of the morainal soils and poor drainage conditions, they typically have high ground-ice content. These ice-rich deposits are sensitive to changes in the thermal regime following the removal of surface vegetation, inundation, or tundra fires. These deposits may be susceptible to frost heaving, surface subsidence (consolidation settlement), gullying and

drainage network disruption and slope stability. Also, active layer detachment slides and retrogressive thaw flows slides or slumps can occur.

Glaciomarine

Glaciomarine landforms deposited during postglacial emergence due to crustal rebound are minor topographic features in the mine site areas (approximately 0.3% of the mine LAA or 108 ha), but these landforms are widespread near Baker Lake. Wave action resulted in extensive reworking of the local ground moraine creating subdued raised beach ridges and depositing fine-grained, nearshore marine sediments. The beach ridges comprise granular, sand-sized materials, which are generally well drained. The fine-grained marine sediments are confined to low-lying areas and are often ice rich.

Organic

Organic deposits are composed predominantly of organic materials resulting from accumulation of vegetative matter and contain at least 30% organic matter by weight. Organic deposits form a dominant terrain either as a veneer or blanket overlying the predominantly fine-grained soils of moraine and glaciolacustrine plains. They are highly compressible and have low strength when thawed. When frozen, they may contain up to 100% ice by volume.

Thick organic landforms represent a relatively minor portion of the total mine LAA, but small localized materials are widespread. Thick peat accumulations occur in low-lying areas. The materials are wet and ice rich.

Bedrock

Bedrock forms prominent ridges, scarps and hills in the LAA. Typically, bedrock is generally freely drained with some poorly drained depressions. There are no records of segregated ice within the bedrock, but the presence of ice is possible in joints and fracture zones. Segregated ice may be present in silt-filled depressions within the region. Outcrops are widespread around the plant/mill site, and are characterized by a jointed or frost shattered upper surface (felsenmeer) resulting in a jagged micro-topography. Bedrock outcrops are also common around the Main Zone Pit, Centre Zone Pit and water storage pit areas. It also occurs north of the proposed overburden and permanent stockpiles. In the Sissons area, outcrops are common in the northeast of Mushroom Lake, east of End Grid Lake and southwest of Lunch Lake. Bedrock outcrop covers approximately 5.0% of the mine LAA or 1,790 ha.

530000 535000 540000 545000 550000 555000 560000 565000 570000 575000

7150000 7145000 7140000 7135000 7130000

Legend

- Local Assessment Area - Terrain
- Lake
- Project Components

Surficial Geology and Common Depositional Landforms

- Alluvium and Marine or Outwash Sediments, Undifferentiated (AO)
- Polydeformed and Metamorposed Supercrustal and Intrusive Rocks (R1)
- Ice-Contact Sediments (Gk)
- Paleoproterozic Dubawnt Supergroup Rocks (R2)
- Outwash Sediments (Go)
- Till Veneer (Tv)
- Deltaic Sediments (Md)
- Hummocky Till (Th)
- Till Blanket (Tb)
- Littoral Sediments (Mr)
- Esker

- Geological boundary (defined)
- Boulder fields
- Marine limit (with elevation in metres) 123
- Beach ridge crests
- Proglacial meltwater channel corridor
- Proglacial meltwater channel (small)
- Sculpted slope with partially eroded till blanket
- Surface thaw slide
- Crag-and-tail landform
- Drumlinoid ridge
- Glacially formed lineation, undifferentiated
- Iceberg scour
- Hummocky moraine
- Ribbed moraine
- Isolated bedrock outcrop
- Prominent frost polygon
- Kettle hole or lake
- Striation (iceflow direction known, unknown, poorly defined)
- Crossed striae (numbers indicate relative age, 1 being the oldest) 1 2
- Roche moutonnée
- Radiocarbon date (see Table 1) 1
- Field observation site

Siamese Lake
Sleek Lake
Pointer Lake
Judge Sissons Lake

N

0 2.5 5 10 15 20 Kilometers

Projection: NAD 1983 UTM Zone 14N
Creator: CDC
Date: 09/15/2011 Scale: 1:125,000
File:
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc, Geological Survey of Canada Map 2120A*

FIGURE 6.1-1
SURFICIAL GEOLOGY AND COMMON DEPOSITIONAL LANDFORMS WITHIN THE MINE LOCAL ASSESSMENT AREA

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6.1.5.2 Glacial Landforms

Landforms around the proposed mill site are dominated by hummocky, bouldery glacial till and scattered boulder till moraines with frequent bedrock outcrops and shattered bedrock features in isolated exposures, elevated plateaus and elongated ridges (drumlins, and other glaciofluvial outwash features). The localized north-northwest trending glacial drumlins preserve evidence of regional ice flow. Glaciofluvial kames and eskers form rare, isolated topographic features. The lower elevations near Baker Lake are partly covered by marine, glaciomarine and lacustrine materials.

6.1.5.3 Permafrost Sensitive Landforms

Permafrost sensitive landforms may be determined based on potential high water and ground-ice content, high frozen bulk density of soil, fine-grained strata with high silt content, position in the landscape, and slope types. This type of landform is assessed as sensitive to changes in the thermal regime and surface conditions.

Permafrost is reflected in well-developed patterned ground and periglacial processes. Evidence of active cryoturbation is found in several locations, where boulders and platy stones are thrust upward to the tundra surface. Patterning is primarily sorted circles, sorted stripes, sorted nets, sorted steps and sorted polygons depending on slope and materials. Sorted circles, nets and steps occur on the glacial till material where there is enough fine material. Sorted polygons are confined to glaciofluvial materials likely due to the high proportion of stone and cobble sized material (Geomatics International 1991).

6.1.5.4 Uncommon Landforms

Some of the landforms left behind by glaciation play a significant role in the lives of local communities. Landforms that have a high value in terms of traditional and cultural importance, potential wildlife habitat, rare plant species and human use are considered uncommon landforms. The most prominent uncommon landforms in the Project area are eskers. Three esker-related landforms have been identified within the mine LAA (Figure 6.1-1). However, they occupy a negligible portion of the area.

6.1.6 Overburden Characteristics

A typical overburden profile comprises a thin, dark brown to black organic topsoil layer, 0.1 m in thickness, underlain by glacial till varying in thickness from approximately one to several metres. The glacial till varies in texture and composition from well-graded silty sand with some gravel and a trace of clay to well-graded gravelly sand with some silt and a trace of clay. Oversize material in the till consists of boulders and cobbles, which tend to be larger and more frequent in proximity to bedrock. In general, the thickness of the till ranges from 0.3 m to 5.0 m. Depth to bedrock generally ranges from 0.3 m to 6.5 m.

6.1.6.1 Water Content and Plasticity

Water content in the permafrost terrain provides information on volumetric ground-ice content. In general, the water content of the glacial till ranges from 7.7% to 50.6%. Sandy gravel till with some silt and trace clay showed maximum water content of 54.2%. The water content of the overburden soils in the proposed mill and End Grid underground mine areas also falls in the same range. The water content of lakebed sediment samples varies from 19.9% to 44.8%.

A glacial till sample, characterized by well-graded silty sand with some gravel and a trace of clay to well graded gravely sand with some silt and a trace of clay, exhibited little to no plasticity (Tier 3, Appendix 6A). Overburden soil in the area north of the Main Zone Pit and Centre Zone Pit exhibit a liquid limit of 18 to 54, plastic limit of 14 to 31, and plasticity index of 3 to 23. In the same area, the glacial till, characterized mainly by sand till with some clay and trace silt exhibit no plasticity. The overburden soil in the proposed mill area and in the area of End Grid underground mine exhibit plasticity index of 6 and 1, respectively. Lakebed sediment samples show no plasticity.

6.1.6.2 Shallow Thermal Conditions

The Kiggavik site is located within the zone of continuous permafrost. The shallow active layer is generally characterized by its limited thickness and continuity. The active layer possesses a seasonal nature as it melts during the summer period (June to September) and is frozen for the rest of the year. Hence, the active layer thickness, also known as the “thaw depth”, increases gradually over the summer months and is believed to reach its maximum depth in August and September. However, the thaw depth depends on various factors including the type and thickness of vegetation cover, organic soils insulation, slope aspect and orientation, the nature of the underlying soil and rock, weather, proximity to waterbodies and human disturbance. The thaw depths in the Kiggavik Project area were estimated from temperature profiles recorded with shallow thermistors and the maximum thaw depths measured with frost depth indicators. In general, the thaw depth ranged from 0.88 m to 3.10 m.

In the area north of the Main Zone Pit, ground-ice depth ranges from 0.60 m to 1.00 m below ground surface. Ground-ice conditions in the glacial till are typically characterized by non-visible ice, well bonded with no excess ice (Nbn) to excess ice (Nbe). In the area north of Centre Zone Pit, ground-ice depth ranges between 0.30 and 0.75 m below ground surface. Ground-ice conditions in the glacial till range from non-visible ice, well bonded with no excess ice (Nbn) to visible ice coatings on soil particles (Vc) and random or irregularly oriented ice formations (Vr) and stratified or distinctly oriented ice formations (Vs). In the south of the Centre Zone Pit, ground-ice occurs at depths of 0.50 and 1.00 m below ground surface. Ground-ice in the silty sand till is non-visible, well bonded with no excess ice (Nbn), whereas ground-ice in the sand and gravel is non-visible, well bonded, excess ice (Nbe).

In the proposed mill area, ground-ice conditions are characterized by non-visible, poorly bonded or friable (Nf) to well bonded with no excess ice (Nbn). However, no ground-ice occurs below a depth of 1.0 m.

The ground-ice content of permafrost soil and rock in the Project area is expected to be between 0% and 10% (dry permafrost) based on regional scale compilation data (Brown et al. 1998). Localized excess ground-ice is expected to be greater in areas such as lowlands that are characterized by poorly drained conditions commonly expressed as patterned ground and other periglacial process features.

The surficial landforms (deposits) along the North All-Season Road between the Kiggavik mine site and the north shore of Baker Lake is comprised mainly of glacial till overlying Precambrian intrusive igneous and metamorphic bedrock. The periglacial geomorphic processes in the area are typical of permafrost conditions associated with excess ground-ice. It is estimated that glacial landforms cover approximately 63% of the North All-Season Road LAA. Alluvial, Marine, Glaciofluvial and Bedrock landforms cover 3.63%, 2.12%, 0.76% and 30.3% of this area, respectively. Organic deposits compose a small percentage of the materials that will be encountered along the route.

Glacial deposit is the most common and widespread surficial deposits in the proposed dock site area. Till veneer and till blanket appear to be the major glacial depositional units in the area. Marine deposits (primarily littoral sediments or its combination with bedrock) are generally noted occur in the south and southeast part of the proposed dock area. Based on results of the geotechnical investigation results, boreholes located on ice indicated that the overburden surface encountered at depths ranging range from 4.20 m to 5.15 m below ice surface in the vicinity of proposed dock site area. The ice thickness was is approximately 2.0 m. The overburden generally consists of medium brown, very fine to coarse, sub-angular and loose to very loose sand with trace silt and trace fine gravel underlain by sand and gravel with occasional cobble. Boreholes located on land revealed that overburden thicknesses vary from 2.93 m to 8.81 m below ground surface. The overburden generally consists of gravely sand underlain by glacial till. The glacial till is typically silty sand till with some fine to coarse gravel and some non-plastic clay. Oversize material in the glacial till consists of cobbles and boulders. Water content of samples of the till range from 7% to 14%.

6.2 SOILS

6.2.1 Soil Classification

Three soil great groups from the Cryosolic Order containing 12 soil subgroups were documented within the Kiggavik RAA during the 2007 to 2010 baseline studies (Table 6.2-1). Cryosols are formed in either mineral or organic materials that have permafrost either within 1 m of the surface or within 2 m if the active layer of the soil profile has been strongly cryoturbated (CSSC 1998). The soil profiles observed within the Kiggavik RAA consisted of a shallow organic

soil layer underlain by glacial tills varying in thickness from less than 1 m on ridges to more than 4 m in depressions (AREVA 2008).

The three Cryosolic Great Groups identified were Turbic Cryosols, Static Cryosols, and Organic Cryosols. Turbic Cryosols have the permafrost layer located within 2 m of the mineral surface and have marked cryoturbation (CSSC 1998). Static Cryosols have permafrost within 1 m of the surface, but show little or no evidence of cryoturbation (CSSC 1998). Static Cryosols generally develop on coarse-textured mineral parent material or thin soils over bedrock or in a wide textural range of recently deposited or disturbed sediments where evidence of cryoturbation is still largely absent, and may contain surface organic horizons less than 40 cm thick (CSSC 1998). Organic Cryosols have permafrost within 1 m of the surface and contain an organic layer greater than 40 cm thick. They develop principally from organic materials and have a surface layer composed of at least 30% organic material (CSSC 1998). Details pertaining to the 12 soil subgroups can be found in the Vegetation and Soils Baseline Report (i.e., Tier 3, Appendix 6B.)

Table 6.2-1 Soil Classes Observed within the Kiggavik RAA

Soil Order	Soil Class	Abbreviation
Static Cryosols	Orthic Static Cryosol	O.SC
	Brunisolic Static Cryosol	BR.SC
	Gleysolic Static Cryosol	GL.SC
	Histic Static Cryosol	H.SC
	Regosolic Static Cryosol	R.SC
	Histic Regosolic Static Cryosol	HR.SC
Turbic Cryosols	Orthic Turbic Cryosol	O.TC
	Brunisolic Turbic Cryosol	BR.TC
	Gleysolic Turbic Cryosol	GL.TC
	Regosolic Turbic Cryosol	R.TC
Organic Cryosols	Terric Fibric Organic Cryosols	TFI.OC
	Terric Humic Organic Cryosols	THU.OC

6.2.2 Baseline Soil Quality

Soil samples were collected within the mine LAA. These samples ranged in texture from sandy clay to sandy loam, with the majority of the soils in the sandy clay loam textural class (see Tier 3, Appendix 6B, Attachment G). The coarse fragment size and content of the soils varies widely from only one or two percent gravels in surface horizons to 90% cobble-size materials at the depth of permafrost. The average coarse fragment content (pebbles, gravel and cobbles) of the developed soil layers (A and B horizons) is approximately 30%.

Soil pH was found to be weakly acid to neutral (average 6.1), ranging from moderately acid (4.8) to slightly basic (7.8) (Table 6.2-2). Soils with low pH likely have low base saturation and relatively low nutrient contents, while those with slightly basic pH likely have high base saturation and relatively high nutrient contents. Neutral to basic soils likely occur where soils are

frequently saturated and there is lateral movement of soil water, such as in the wet graminoid and graminoid tundra communities (Organic Cryosols).

Chemical analysis of soil samples revealed that, although mean concentrations for all analytes measured were below the CCME industrial soil guidelines (CCME 2009), some samples contained naturally elevated concentrations of some analytes (Table 6.2-2; see Tier 3, Appendix 6B for detailed data). Five soil samples had elevated trace element concentrations. One sample had elevated arsenic concentration, two samples had elevated copper concentration, and one sample had elevated selenium concentration relative to the CCME (2009) guidelines. One sample from the RAA contained nickel concentrations that exceeded the guidelines.

The baseline soil trace element and radionuclide data were compared to CCME guidelines (CCME 2009). Radionuclides are frequently elevated in soils above uranium ore deposits, which may also have elevated concentrations of other trace elements. Baseline radionuclide and trace element concentrations are established so that naturally elevated concentrations are not attributed to mining during operations and post-closure monitoring. The guidelines are for general guidance only, and site-specific conditions will be considered in the effects assessment for soil quality.

6.2.3 Baseline Soil Quantity

The soils predominantly consist of a shallow organic veneer overlying fine to coarse-textured glacial till blankets, which vary in thickness from less than 1 m on bedrock ridges to more than 4 m in depressions. The growth medium layer (i.e., the organic layers plus organic enriched mineral soil, or topsoil depth) identified during the baseline studies varied from 3 to 31 cm, with an average depth of approximately 11 cm. Vegetation roots were frequently observed in the B horizon. Rooting depth was frequently restricted by frozen or strongly cryoturbated soil (see Tier 3, Appendix 6B, Attachment G). Approximately 54% of the topsoil depth in any given area is peat organic material. The till-derived mineral fraction of the soils is medium textured, with coarse fragment size typically ranging from gravel to cobble. Coarse fragment content is typically low at the surface, and increases with depth.

Table 6.2-2 Soil Chemistry Data for the LAA and RAA (2007–2009) Compared with CCME Guideline Levels[1]

Parameter	Units	Mine LSA							RAA					CCME Guidelines (Industrial)
		Sample Number					Range		Sample Number			Range		
		2007[a]	2008[b]	Total	Mean	SD	Min	Max	2009[c]	Mean	SD	Min	Max	
pH	pH	6	50	56	6.1	0.76	4.8	7.8	ND	ND	ND	ND	ND	N/A
Moisture (mineral soil)	%	6	0	6	16	4.8	14	22	10	11	1.8	9.3	14.3	N/A
Moisture (peat)	%	5	0	5	78	3.6	74	84	ND	ND	ND	ND	ND	N/A
Aluminum	µg/g	11	0	11	17,227	11,318	4,400	37,200	10	7,594	3,960	3,500	16,200	N/A
Antimony	µg/g	11	50	61	4.1	2	<0.1	5.0	10	<0.2	N/A	<0.2	N/A	40
Arsenic	µg/g	11	50	61	3.7	2	1.2	13.6	10	3.1	1.4	1.4	5.8	12
Barium	µg/g	11	50	61	156	177	27	910	10	138	202	48	710	2,000
Beryllium	µg/g	11	50	61	0.38	0	<0.5	2.1	10	0.4	0.11	0.3	0.6	8
Boron	µg/g	11	0	11	16	20	<1	54	10	15	19	0.5	48	N/A
Cadmium	µg/g	11	50	61	0.26	0	<0.1	0.89	10	<0.1	N/A	<0.1	N/A	22
Chromium	µg/g	11	50	61	20	7	4.6	44	10	15	14	6.8	54	87
Cobalt	µg/g	11	50	61	4.3	2	1.3	8.9	10	4.0	3.3	1.6	13	300
Copper	µg/g	11	50	61	14	19	2.2	96	10	6.3	6.1	2	23	91
Iron	µg/g	11	0	11	12,391	5,218	5,700	25,000	10	11,810	4,896	7,400	25,100	N/A
Lead	µg/g	11	50	61	15	10	0.74	85	10	11	6.5	4.1	23	600
Manganese	µg/g	11	0	11	150	77	11	280	10	115	53	61	230	N/A
Mercury	µg/g	11	50	61	0.012	0	<0.005	0.12	0	ND	ND	ND	ND	50
Molybdenum	µg/g	11	50	61	2.0	1	0.2	6.9	10	0.2	0.067	0.1	0.3	40
Nickel	µg/g	11	50	61	13	6	<5	34	10	14	17	5.1	61	50
Selenium	µg/g	11	50	61	0.92	0	<0.1	<4.0	10	0.08	0.079	0.05	0.3	2.9
Silver	µg/g	11	50	61	0.84	0	<0.1	1.0	10	<0.1	N/A	<0.1	N/A	40

Table 6.2-2 Soil Chemistry Data for the LAA and RAA (2007–2009) Compared with CCME Guideline Levels[1] (cont'd)

Parameter	Units	Mine LSA							RAA					CCME Guidelines (Industrial)
		Sample Number			Mean	SD	Range		Sample Number	Mean	SD	Range		
		2007[a]	2008[b]	Total			Min	Max	2009[c]			Min	Max	
Strontium	µg/g	11	0	11	73	18	47	110	10	115	102	66	400	N/A
Thallium	µg/g	11	50	61	0.44	0	<0.05	0.50	10	<0.2	N/A	<0.2	N/A	1
Tin	µg/g	11	50	61	2.1	1	<0.05	2.5	10	0.08	0.049	0.05	0.2	300
Titanium	µg/g	11	0	11	303	96	54	410	10	608	419	210	1,600	N/A
Uranium	µg/g	11	0	11	2.5	2	0.65	6.0	10	1.3	0.56	0.8	2.4	300
Vanadium	µg/g	11	50	61	19	7	4.3	47	10	22	13	13	59	130
Zinc	µg/g	11	50	61	19	8	6.2	50	10	20	13	9.1	56	360
Lead-210	Bq/g	11	31[b]	42[b]	0.020	0.024	<0.006	0.13	10	<0.04	N/A	<0.04	N/A	N/A
Polonium-210	Bq/g	11	31[b]	42[b]	0.036	0.070	0.004	0.47	10	0.022	0.010	0.005	0.03	N/A
Radium-226	Bq/g	11	31[b]	42[b]	0.039	0.030	<0.01	0.14	10	0.035	0.020	0.005	0.08	N/A
Thorium-230	Bq/g	11	31[b]	42[b]	0.037	0.024	0.017	0.13	10	0.020	0.012	0.01	0.04	N/A
Thorium-232	Bq/g	0	31[b]	31[b]	0.028	0.012	<0.02	0.06	10	0.032	0.014	0.01	0.05	N/A

NOTES:

Shaded value indicates guideline level is exceeded

[1] Based on Table 5.2-3 in Tier 3, Appendix 6B

[a] Includes mineral soil samples collected from all six sampling locations and peat samples collected from five of the sampling locations (not SIS3)

[b] Includes 20 individual samples (two from each sampling location) and 10 composite samples (one composite from each sampling location), plus an extra sample collected at KIG4

[c] Includes 10 samples collected from two sampling locations in 2009

ND = No data

N/A = Not applicable

SD = Standard deviation

CCME = Canadian Council of Ministers of the Environment Soil Quality Guideline (CCME 2009)

6.3 VEGETATION

6.3.1 Species

Field surveys completed between 1979 and 2009 within the Kiggavik area identified 170 vascular plant species, 21 bryophyte species and 75 lichen species. During the 2008/2009 vegetation baseline surveys, 88 vascular plants and 20 lichen species were identified within the RAA. No listed species were observed within the mine LAA, road LAAs or RAA.

Two vegetation species listed on Schedule 1 of SARA occur in Nunavut: felt-leaf willow (*Salix silicicola)* and Porsild's Bryum (*Mielichhoferia macrocarpa)*. Felt-leaf willow is listed as a species of Special Concern and has been observed near Pelly Lake, Northwest Territories, which is located outside of the RAA (SARPR 2011). Porsild's Bryum is a moss species listed as Threatened. The only recorded location for Porsild's Bryum in Nunavut is on Ellesmere Island (SARPR 2011). Neither of these species was observed during the baseline surveys.

6.3.2 Communities

6.3.2.1 Ecological Land Classification Units

The RAA is dominated by tundra vegetation interspersed with lichen-dominated bedrock outcroppings and boulder fields. The tundra vegetation is characterized by short shrubs such as dwarf birch, willows and heath species, as well as sedges and grasses, herbs, mosses and lichens. An ecological classification scheme containing 15 ELC units occur within the LAAs and RAA and is summarized in Table 6.3-1.

Table 6.3-1 Ecological Land Classification Units

Category	ELC Unit	Description
Anthropogenic	Disturbance	Anthropogenic disturbance on the landscape, located primarily near the community of Baker Lake
Unclassified	Cloud/ Shadow	Areas of cloud and associated shadows present within the source Landsat image
Non Vegetated	Sand	Areas of exposed sand typically found in dry river or lake beds, or beach ridge uplands
	Gravel	Areas of exposed gravel typically found in dry river or lake beds, eskers or beach ridge uplands
Upland	Rock Association	Areas of bedrock outcrops and boulder fields
	Graminoid Tundra	Sedge communities in mesic areas, including tussock/hummock formations. Usually found on peat substrates. Dominant plant species include mesic sedges (*Carex spp*.), with small amounts of water sedge, tall cottongrass, shrubs and forbs

Table 6.3-1 Ecological Land Classification Units (cont'd)

Category	ELC Unit	Description
Upland (cont'd)	Graminoid/ Shrub Tundra	A transition between Graminoid Tundra and Shrub Tundra communities; occurs in mesic areas with 25 to 50% cover of shrubs that are less than 40 cm in height. Graminoids, mosses, and lichens are also present
	Shrub Tundra	Mesic moisture regime communities with at least 50% cover of shrubs such as dwarf birch (*Betula glandulosa*) and diamond leaf willow (*Salix planifolia*); the understorey consists of some lichens and herbs; moss may be present
	Shrub/ Heath Tundra	A transitional unit between Shrub Tundra and Heath Tundra; occurs on well to moderately drained soils (mesic-xeric moisture regime) with between 30 and 50% cover of erect shrubs that are less than 40 cm tall; graminoids, mosses, and lichens may be present
	Heath Tundra	Occurs on well to moderately drained soils (mesic-xeric moisture regime) and is dominated by ericaceous shrubs, lichens and some graminoids; vegetative cover typically exceeds 70% with less than 30% exposed rock; erect shrubs are present but to a lesser degree than the shrub/heath tundra unit (less than 30%)
	Heath Upland	Occurs on rocky substrate with xeric moisture regime; over 70% vegetation cover including ericaceous shrubs, lichens and graminoids; typical species include bog blueberry (*Vaccinium uliginosum*), white arctic mountain heather (*Cassiope tetragona*), northern Labrador tea (*Ledum decumbens*), black crowberry (*Empetrum nigrum*) and the lichen ballroom dervish (*Cetraria nivalis*)
	Heath Upland/ Rock Complex	A transition between Heath Upland and Rock Association, this unit is dominated by ericaceous shrubs and lichens with rock or boulder substrate; closely resembles both parent communities
	Lichen Tundra	Develops on well-drained and poorly developed soils (xeric moisture regime); substrate is typically sand, gravel or cobble; unit is most often associated with esker ridges and ridged moraine landforms; green witch's hair lichen (*Alectoria ochroleuca*), *Bryoria nitidula*, crinkled snow lichen (*Cetraria cucullata*), Iceland moss (*Cetraria islandica*), ballroom dervish, and lesser green reindeer lichen (*Cladina mitis*) are the dominant species
Wetland	Water	Water features identified in the imagery; waterbodies greater than 0.75 ha and rivers wider than 75 m are distinguishable in Landsat imagery
	Wet Graminoid	Occurs in poorly drained areas (hygric moisture regime) and around water features; water sedge (*Carex aquatilis)* and tall cottongrass (*Eriophorum angustifolium*) are dominant species; moss is also present

6.3.2.2 Wetlands

Wetlands are areas saturated with water long enough to promote aquatic processes, as indicated by poorly drained soils, hydrophytic vegetation and other biological activity adapted to a wet environment (NWWG 1997). In the low arctic, wetland definitions have been refined to include only areas waterlogged throughout the year (Zoltai and Pollett 1983; Boch 1974; Tarnocai and Zoltai 1988). Tarnocai and Zoltai (1988) note that, in the low arctic, "large expanses of tundra, covered with tussock forming graminoid species such as *Carex bigelowii* and *Eriophorum vaginatum* are not considered to be wetlands since they are not waterlogged throughout the year." As such, the Graminoid Tundra ELC unit is considered an upland ELC unit. Units with more permanent water were considered wetland (i.e., the Water and Wet Graminoid ELC units).

6.3.3 Species of Value to Inuit

During the IQ studies, interviews with Elders identified vegetation species that were harvested for food. The majority of the responses from the Elders focussed on berry-producing vegetation species such as black berries (*Empetrum nigrum)*, cloudberries (*Rubus chamaemorus)*, blueberries (*Vaccinium uliginosum)*, and cowberries (*Vaccinium vitis-idaea)*. During the baseline studies, 11 ELC units were found to have moderate to high potential to support these species (Table 6.3-2).

Table 6.3-2 ELC Units Containing Species of Traditional Value to Inuit

ELC Unit	Species of Traditional Value to Inuit			
	Black Berries	Cloudberries	Blueberries	Cowberries
	Empetrum nigrum	*Rubus chamaemorus*	*Vaccinium uliginosum*	*Vaccinium vitis-idaea*
Wet Graminoid			x	
Graminoid Tundra			x	x
Graminoid/ Shrub Tundra			x	
Shrub Tundra			x	x
Shrub/Heath Tundra	x		x	x
Heath Tundra	x		x	x
Heath Upland	x	x	x	x
Heath Upland/Rock Complex	x		x	x
Lichen Tundra	x	x		x
Gravel	x			
Rock Association	x			

NOTE:
x indicates that species occurs with over 10% cover in at least one ELC plot, indicating moderate to high potential to occur within the ELC unit, while no symbol indicates that species occurs with less than 10% cover in all ELC plots, indicating low potential to occur within the ELC unit.

6.3.4 Plant Tissue Chemistry

Analyte concentrations were analyzed from plant tissue samples collected between 2007 and 2009. Sampled tissue included primarily sedge, lichen and berries, as well as some 2007 foliage samples collected from birch, willow and blueberry bush. Mean concentrations for each tissue type are summarized in Tables 6.3-3 to 6.3-6.

Table 6.3-3 Plant Tissue Chemistry Data (Berries) for the Mine LAA and RAA (2007–2009)

Parameter	Unit	Mine LAA (2007/2008)					RAA (2009)				
		n	Mean	SD	Range		n	Mean	SD	Range	
					Min	Max				Min	Max
Aluminum	µg/g	50	7.2	14	<2	75.2	2	5.1	2.1	3.6	6.5
Antimony	µg/g	50	0.010	0.015	<0.010	<0.10	2	0.050	0	<0.1	<0.1
Arsenic	µg/g	50	0.0078	0.0071	<0.010	0.026	2	0.025	0	<0.05	<0.05
Barium	µg/g	50	4.4	6.4	0.813	27	2	10	0.78	9.9	11
Beryllium	µg/g	50	0.045	0.015	<0.01	<0.10	2	0.0050	0	<0.01	<0.01
Boron	µg/g	6	27	17	14	60	2	5.0	0	5	5
Cadmium	µg/g	50	0.037	0.078	<0.005	0.36	2	0.013	0.011	<0.01	0.02
Chromium	µg/g	50	0.46	0.92	<0.10	4.94	2	0.25	0	<0.5	<0.5
Cobalt	µg/g	50	0.017	0.016	<0.02	0.067	2	0.023	0.025	<0.01	0.04
Copper	µg/g	50	1.2	1.4	0.537	7	2	4.4	0.14	4.3	4.5
Iron	µg/g	6	17	6.6	12	30	2	10	0	10	10
Lead	µg/g	50	0.012	0.0077	<0.01	0.05	2	0.030	0	0.03	0.03
Manganese	µg/g	50	50	69	6.07	310	2	75	21	60	90
Mercury	µg/g	50	0.0034	0.0080	<0.0010	<0.05	ND	ND	ND	ND	ND
Molybdenum	µg/g	50	0.092	0.22	<0.010	1.5	2	0.075	0.035	<0.1	0.1
Nickel	µg/g	50	0.51	0.65	<0.1	2.99	2	0.70	0.29	0.49	0.9
Selenium	µg/g	50	0.091	0.025	<0.05	<0.20	2	0.025	0	<0.05	<0.05
Silver	µg/g	6	0.0050	0	<0.01	<0.01	2	0.005	0	<0.1	<0.1
Strontium	µg/g	50	0.92	1.4	0.179	7.2	2	11	7.4	5.6	16
Thallium	µg/g	50	0.0074	0.0066	<0.010	<0.05	2	0.025	0	<0.05	<0.05
Tin	µg/g	50	0.11	0.062	<0.05	0.336	2	0.025	0	<0.05	<0.05
Titanium	µg/g	6	0.25	0.28	0.06	0.79	2	0.19	0.078	0.13	0.24
Uranium	µg/g	50	0.0017	0.0015	<0.002	0.0059	2	0.0050	0	<0.01	<0.01
Vanadium	µg/g	50	0.050	0	<0.1	<0.1	2	0.050	0	<0.1	0.1

Table 6.3-3 Plant Tissue Chemistry Data (Berries) for the Mine LAA and RAA (2007–2009) (cont'd)

Parameter	Unit	Mine LAA (2007/08)					RAA (2009)				
					Range					Range	
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Zinc	µg/g	50	17	12	1.31	40.4	2	8.9	1.6	7.8	10
Bismuth	µg/g	44	0.015	0	<0.03	<0.03	ND	ND	ND	ND	ND
Calcium	µg/g	44	273	100	88.6	479	ND	ND	ND	ND	ND
Lithium	µg/g	44	0.050	0	<0.10	<0.10	ND	ND	ND	ND	ND
Magnesium	µg/g	44	84	11	51.2	108	ND	ND	ND	ND	ND
Moisture	%	50	87	1.2	84.7	89.8	2	82	2.5	80.65	84.19
Lead-210	Bq/g	16	0.0071	0.0044	<0.002	0.014	2	0.060	0.041	0.031	0.089
Polonium-210	Bq/g	16	0.0068	0.0039	0.002	0.014	2	0.0085	0.0035	0.006	0.011
Radium-226	Bq/g	16	0.0011	0.0009	<0.0005	0.004	2	0.0020	0	0.002	0.002
Thorium-230	Bq/g	16	0.0017	0.0010	<0.0004	<0.005	2	0.0010	0	<0.002	<0.002
Thorium-232	Bq/g	10	0.0025	0.0002	<0.004	<0.005	2	0.0010	0	<0.002	<0.002

NOTE:

Data are for samples collected at locations indicated in Tier 3, Appendix 6B, Section 4.

All 2007 LSA samples run individually for both metals and radionuclide analysis.

All 2008 LSA samples run individually for metals analysis; 44 LSA berry samples were combined into 10 composite samples for radionuclide analysis; 100 LSA sedge/lichen samples from 2008 were combined into 35 composite samples and 20 discrete samples for radionuclide analysis.

All 2009 RAA samples run individually for metals and radionuclide analysis.

ND = No data

n = Sample size

SD = Standard deviation

Table 6.3-4 Plant Tissue Chemistry Data (Lichen) for the Mine LAA and RAA (2007–2009)

Parameter	Unit	Mine LAA (2007/08)					RAA (2009)				
					Range					Range	
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Aluminum	µg/g	56	178	276	16	1640	10	116	72	66	310
Antimony	µg/g	56	0.021	0.011	<0.020	<0.10	10	0.050	0	<0.1	<0.1
Arsenic	µg/g	56	0.091	0.069	<0.020	0.405	10	0.051	0.028	<0.05	0.09
Barium	µg/g	56	47	33	10.1	243	10	55	34	19	130
Beryllium	µg/g	56	0.16	0.061	<0.01	<0.40	10	0.015	0.015	<0.01	0.05
Boron	µg/g	6	2.5	0.55	2	3	10	0.70	0.26	<1	1
Cadmium	µg/g	56	0.11	0.059	0.019	0.296	10	0.10	0.055	0.03	0.21
Chromium	µg/g	56	1.4	3.0	<0.2	17.9	10	0.25	0	<0.5	<0.5
Cobalt	µg/g	56	0.25	0.55	<0.060	3.84	10	0.15	0.11	0.05	0.37
Copper	µg/g	56	2.1	1.1	0.6	6.19	10	1.2	0.51	0.56	2.4
Iron	µg/g	6	160	97	78	310	10	126	122	50	470
Lead	µg/g	56	0.69	1.0	0.104	6.96	10	0.77	0.80	0.29	3
Manganese	µg/g	56	199	119	27	652	10	202	73	90	350
Mercury	µg/g	56	0.035	0.023	0.0041	0.1	ND	ND	ND	ND	ND
Molybdenum	µg/g	56	0.28	0.52	<0.030	3.41	10	0.055	0.016	<0.1	0.1
Nickel	µg/g	56	1.3	1.6	<0.30	9.09	10	0.49	0.25	0.21	0.94
Selenium	µg/g	56	0.32	0.12	<0.05	<0.80	10	0.025	0	<0.05	<0.05
Silver	µg/g	6	0.034	0.049	<0.01	0.13	10	0.0085	0.0078	<0.01	0.03
Strontium	µg/g	56	13	6.8	4.17	44.5	10	33	32	6.8	100
Thallium	µg/g	56	0.019	0.0078	<0.020	0.069	10	0.025	0	<0.05	<0.05
Tin	µg/g	56	0.083	0.024	<0.05	<0.20	10	0.047	0.058	<0.05	0.21
Titanium	µg/g	6	6.5	3.2	3.2	11	10	4.8	4.4	2.2	17
Uranium	µg/g	56	0.37	2.4	<0.006	18.1	10	0.014	0.011	<0.01	0.04

Table 6.3-4 Plant Tissue Chemistry Data (Lichen) for the Mine LAA and RAA (2007–2009) (cont'd)

Parameter	Unit	Mine LAA (2007/08)					RAA (2009)				
					Range					Range	
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Vanadium	µg/g	56	0.36	0.66	<0.20	4.67	10	0.20	0.15	<0.1	0.6
Zinc	µg/g	56	28	9.2	10.9	60	10	19	3.6	13	24
Bismuth	µg/g	50	0.067	0.10	<0.060	0.726	ND	ND	ND	ND	ND
Calcium	µg/g	50	3431	1663	933	10700	ND	ND	ND	ND	ND
Lithium	µg/g	50	0.30	0.62	<0.20	4.34	ND	ND	ND	ND	ND
Magnesium	µg/g	50	532	156	212	1080	ND	ND	ND	ND	ND
Moisture	%	56	34	20	9.98	68	ND	ND	ND	ND	ND
Lead-210	Bq/g	34	0.45	0.085	0.26	0.64	10	0.58	0.068	0.48	0.71
Polonium-210	Bq/g	34	0.40	0.079	0.15	0.58	10	0.53	0.11	0.36	0.65
Radium-226	Bq/g	34	0.010	0.030	<0.001	0.18	10	0.0045	0.0031	<0.001	0.011
Thorium-230	Bq/g	34	0.0095	0.041	<0.0005	0.24	10	0.0020	0.0014	<0.003	0.006
Thorium-232	Bq/g	28	0.0025	0	<0.005	<0.005	10	0.0015	0	<0.003	<0.003

NOTES:

Data are for samples collected at locations indicated Tier 3, Appendix 6B, Section 4.

All 2007 LSA samples run individually for both metals and radionuclide analysis.

All 2008 LSA samples run individually for metals analysis; 44 LSA berry samples were combined into 10 composite samples for radionuclide analysis; 100 LSA sedge/lichen samples from 2008 were combined into 35 composite samples and 20 discrete samples for radionuclide analysis.

All 2009 RAA samples run individually for metals and radionuclide analysis.

ND = No data

n = Sample size

SD = Standard deviation

Table 6.3-5 Plant Tissue Chemistry Data (Sedges) for the Mine LAA and RAA (2007–2009)

Parameter	Unit	Mine LAA (2007/08)					RAA (2009)				
					Range					Range	
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Aluminum	µg/g	56	65	116	3.4	839	10	59	40	1.4	140
Antimony	µg/g	56	0.016	0.012	<0.02	<0.10	10	0.050	0	<0.1	<0.1
Arsenic	µg/g	56	0.057	0.091	<0.02	0.51	10	0.034	0.019	<0.05	0.07
Barium	µg/g	56	36	21	8.51	97	10	71	29	8.9	110
Beryllium	µg/g	56	0.10	0.044	<0.01	<0.40	10	0.012	0.014	<0.01	0.05
Boron	µg/g	6	9.0	3.3	5	15	10	3.3	2.2	<1	7
Cadmium	µg/g	56	0.045	0.032	<0.01	0.171	10	0.066	0.050	<0.01	0.18
Chromium	µg/g	56	1.1	3.2	<0.20	22.8	10	0.25	0	<0.5	<0.5
Cobalt	µg/g	56	0.16	0.19	0.02	0.868	10	0.15	0.094	<0.01	0.29
Copper	µg/g	56	2.2	0.91	0.602	4.4	10	2.4	1.1	0.37	4.3
Iron	µg/g	6	112	101	16	300	10	87	53	4.8	220
Lead	µg/g	56	0.19	0.20	0.02	0.947	10	0.41	0.20	0.02	0.71
Manganese	µg/g	56	159	108	39.9	560	10	400	306	50	1100
Mercury	µg/g	56	0.012	0.010	0.002	0.0445	ND	ND	ND	ND	ND
Molybdenum	µg/g	56	0.57	0.89	<0.02	4.8	10	0.58	0.32	0.05	1.1
Nickel	µg/g	56	1.1	1.7	0.24	12.5	10	0.81	0.43	0.06	1.6
Selenium	µg/g	56	0.21	0.085	<0.05	<0.80	10	0.025	0	<0.05	<0.05
Silver	µg/g	6	0.025	0.033	<0.01	0.09	10	0.0050	0	<0.01	<0.01
Strontium	µg/g	56	8.4	5.0	1.99	25.1	10	35	35	1.6	110
Thallium	µg/g	56	0.013	0.0050	<0.02	<0.05	10	0.025	0	<0.05	<0.05
Tin	µg/g	56	0.068	0.10	<0.05	0.82	10	0.025	0	<0.05	<0.05
Titanium	µg/g	6	0.68	1.0	0.11	2.7	10	1.7	1.8	0.06	6
Uranium	µg/g	56	0.44	2.1	<0.004	13.9	10	0.016	0.013	<0.01	0.04
Vanadium	µg/g	56	0.17	0.24	<0.10	1.73	10	0.080	0.079	<0.1	0.3

Table 6.3-5 Plant Tissue Chemistry Data (Sedges) for the Mine LAA and RAA (2007–2009) (cont'd)

Parameter	Unit	Mine LAA (2007/08)					RAA (2009)				
					Range					Range	
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Zinc	µg/g	56	19	14	6.89	100	10	42	23	3.6	70
Bismuth	µg/g	50	0.035	0.0088	<0.06	<0.12	ND	ND	ND	ND	ND
Calcium	µg/g	50	1767	963	542	5960	ND	ND	ND	ND	ND
Lithium	µg/g	50	0.14	0.12	<0.20	0.89	ND	ND	ND	ND	ND
Magnesium	µg/g	50	413	121	183	740	ND	ND	ND	ND	ND
Moisture	%	56	53	13	15.6	70.67	ND	ND	ND	ND	ND
Lead-210	Bq/g	33	0.18	0.12	0.007	0.46	10	0.32	0.092	0.14	0.43
Polonium-210	Bq/g	33	0.14	0.083	0.012	0.29	10	0.26	0.078	0.12	0.38
Radium-226	Bq/g	33	0.014	0.045	0.001	0.26	10	0.0047	0.0025	<0.001	0.008
Thorium-230	Bq/g	33	0.0075	0.021	<0.0005	0.12	10	0.0014	0.0009	<0.002	0.004
Thorium-232	Bq/g	27	0.0034	0.0036	<0.004	0.02	10	0.0011	0.0002	<0.002	<0.003

NOTES:

Data are for samples collected at locations indicated Tier 3, Appendix 6B, Section 4.

All 2007 LSA samples run individually for both metals and radionuclide analysis.

All 2008 LSA samples run individually for metals analysis; 44 LSA berry samples were combined into 10 composite samples for radionuclide analysis; 100 LSA sedge/lichen samples from 2008 were combined into 35 composite samples and 20 discrete samples for radionuclide analysis.

All 2009 RAA samples run individually for metals and radionuclide analysis.

ND = No data

n = Sample size

SD = Standard deviation

Table 6.3-6 Plant Tissue Chemistry Data (Foliage) for the Mine LSA (2007)

Parameter	Unit	n	Mean	SD	Range	
					Min	Max
Aluminum	µg/g	18	33	25	8.6	100
Antimony	µg/g	18	0.050	0	<0.1	<0.1
Arsenic	µg/g	18	0.031	0.025	<0.05	0.13
Barium	µg/g	18	87	30	55	160
Beryllium	µg/g	18	0.0050	0	<0.01	<0.01
Boron	µg/g	18	12	3.6	9	21
Cadmium	µg/g	18	1.2	1.5	0.08	5
Chromium	µg/g	18	0.27	0.082	<0.5	0.6
Cobalt	µg/g	18	0.42	0.30	0.05	1
Copper	µg/g	18	6.8	2.1	4.3	12
Iron	µg/g	18	28	5.2	22	37
Lead	µg/g	18	0.11	0.058	0.04	0.21
Manganese	µg/g	18	488	302	100	1300
Mercury	µg/g	18	0.025	0	<0.05	<0.05
Molybdenum	µg/g	18	0.12	0.16	<0.1	0.6
Nickel	µg/g	18	1.8	1.0	0.57	4.1
Selenium	µg/g	18	0.025	0	<0.05	<0.05
Silver	µg/g	18	0.011	0.014	<0.01	0.05
Strontium	µg/g	18	18	13	5	47
Thallium	µg/g	18	0.025	0	<0.05	<0.05
Tin	µg/g	18	0.027	0.0082	<0.05	0.06
Titanium	µg/g	18	4.2	12	0.3	49
Uranium	µg/g	18	0.0053	0.0012	<0.01	0.01
Vanadium	µg/g	18	0.16	0.41	<0.1	1.8
Zinc	µg/g	18	132	98	32	380
Bismuth	µg/g	ND	ND	ND	ND	ND
Calcium	µg/g	ND	ND	ND	ND	ND
Lithium	µg/g	ND	ND	ND	ND	ND
Magnesium	µg/g	ND	ND	ND	ND	ND
Moisture	%	18	53	3.0	48.25	58.63
Lead-210	Bq/g	18	0.11	0.028	0.057	0.16
Polonium-210	Bq/g	18	0.089	0.025	0.045	0.13
Radium-226	Bq/g	18	0.0043	0.0029	0.0012	0.014
Thorium-230	Bq/g	18	0.00063	0.0004	<0.0004	0.002
Thorium-232	Bq/g	ND	ND	ND	ND	ND

NOTES:
Data are for samples collected at locations indicated in Tier 3, Appendix 6B, Section 4.
All samples run individually for both metals and radionuclide analysis.
Samples consisted of foliage collected from willow, birch and blueberry bush.
ND = No data ; n = Sample size ; SD = Standard deviation

7 EFFECTS ASSESSMENT FOR TERRAIN

7.1 SCOPE OF THE ASSESSMENT FOR TERRAIN

7.1.1 Project-Environment Interactions and Environment Effects

The Kiggavik Project has the potential to affect terrain through changes in permafrost conditions and terrain stability, and changes in landforms. Protection of the existing permafrost conditions and thermal regime is closely associated with stability of the terrain and landforms, including the stability of Project elements.

Key issues related to Project effects on terrain include:

- change in terrain and landforms due to disturbance of eskers and other significant and sensitive landforms
- change in permafrost conditions and terrain stability due to vegetation clearing, potential changes in slope, redirection of surface drainage patterns, changes in sub-surface flow and blasting

Project activities that are the focus of the terrain assessment are summarized in Table 7.1-1.

Table 7.1-1 Project-Environment Interactions and Effects on Terrain

Construction			
In-Water Construction	Construct freshwater diversions and site drainage containment systems (dykes, berms, collection ponds)	2	1
On-Land Construction	Site clearing and pad construction (blasting, earth-moving, loading, hauling, dumping, crushing)	2	2
	Road and airstrip construction	1	2
	Aggregate sourcing	2	2
	Construct foundations	2	2
Operation			
Mining	Mining ore (blasting, loading, hauling)	2	2
	Special waste (blasting, loading, hauling)	2	2
	Clean waste (blasting, loading, hauling)	2	2
Tailings Management	Placement of tailings slurry, consolidation of tailings and pumping of TMF supernatant	2	0

Table 7.1-1 Project-Environment Interactions and Effects on Terrain (cont'd)

Project Component	Project Activities	Environmental Effect	
		Change in Permafrost and Terrain Stability	Change in Landforms
Final Closure			
In-Water Decommissioning	Water transfers and discharge	2	0
On-Land Decommissioning	Remove site pads (blasting, earth-moving, loading, hauling, dumping)	2	2
	Backfilling	2	0
	Contouring	2	0

Construct Freshwater Diversions and Site Drainage

Site preparation, excavation, and construction of freshwater diversions and site drainage channels (such as dykes, berms and collection ponds) could have potential effects to slope stability, shoreline erosion, slides, rock falls and slumping in surficial deposits and shallow bedrock. These effects could further accelerate changes in landforms. However, the following measures will be taken into consideration to mitigate these potential adverse effects during design and construction phases of the Project (see details in Tier 3, Appendix 2E).

- Natural ground may be used as one channel side when the channel is transverse across a slope and a berm is constructed on the opposite side to contain the flow.
- The diversion channels will be constructed maintain the structural integrity of the channel, depending on the terrain and geo-technical conditions.
- Erosion control structures will be incorporated into the design of the freshwater diversion channels to reduce the potential for erosion and sediment transport.
- Freshwater diversion channels will be designed to prevent channel deformation caused by melting of permafrost located adjacent to the channel.
- An ongoing monitoring and maintenance program focussing on the structural integrity of the freshwater diversion channel will occur.

With the implementation of these mitigation measures, the residual effects from the construction of freshwater diversions and site drainage on landforms are anticipated to be minor; hence, the level of interaction between Project activities and the VEC is ranked as 1 and not carried forward for further assessment.

Road and Airstrip Construction

The road and airstrip will be built with granular materials (fill method) placed on top of the existing terrain surface. The total embankment fills for the road construction will range from 0.5 m (exposed rock area) to 1.8 m (wet terrain condition with medium to high ground-ice content), whereas the total embankment fill for the airstrip site will be a minimum of 2 m thick. By placing materials on top of the existing terrain, the surface insulation layer that protects the shallow permafrost regime will not be disturbed; therefore, the potential for thawing of the permafrost layer at the road location is reduced, which also prevents any terrain stability issues. As well, any adverse environmental effect related to erosion that is influenced by thawing of the permafrost layer is also reduced.

The proposed road and airstrip are designed and routed on higher ground as these areas tend to contain less ground-ice, fewer drainage areas to cross, are less prone to snow drifts, and generally contain more bedrock. Routing the proposed road on higher ground will reduce geotechnical issues and road fill required during construction. This will also reduce potential maintenance issues (e.g., snow drifts) throughout the life of the Project. Permafrost conditions and terrain stability are not anticipated to be affected by development of the winter road options. Adding granular fill to create a level travel surface, winter roads will be an ice road.

The road construction will likely impede water courses and change the existing drainage pattern. Appropriate culverts will be designed and placed in areas crossed by the road options where surface drainage is apparent.

In the presence of appropriate mitigation measures, the residual effects from road and airstrip construction on permafrost condition and terrain stability are anticipated to be not significant and hence the level of interaction between Project activities and the VEC is ranked as 1 and not carried forward for further assessment

7.1.2 Measurable Parameters

Table 7.1-2 lists the measurable parameters used to assess Project effects on terrain and the rationale for their selection.

Table 7.1-2 Measurable Parameters for Terrain

VEC	Environmental Effect	Measurable Parameters	Rationale
Terrain	Change in Permafrost and Terrain Stability	Thaw depth, ground-ice content	Vegetation clearing, potential change in slope, redirection of surface drainage patterns, changes in sub-surface flow, and blasting may result in changes to permafrost conditions and terrain stability
	Change in Landforms	Direct loss of uncommon landforms from Project footprint	Disturbance to eskers may result in changes to culturally and traditionally significant landforms

7.1.3 Residual Environmental Effects Criteria for Terrain

Project residual environmental effects on terrain are characterized quantitatively and qualitatively using the following attributes: direction, magnitude, geographic extent, duration, frequency, and reversibility. Definitions of these attributes are presented in Table 7.1-3.

Table 7.1-3 Residual Environmental Effects Criteria for Terrain

Attribute	Rating	Definition
Direction	Positive	Improvement in permafrost condition, terrain stability or change in landforms relative to baseline conditions
	Neutral	No change in permafrost condition, terrain stability or change in sensitive landforms relative to baseline conditions
	Adverse	Reduction in permafrost condition, terrain stability or change in sensitive landforms relative to baseline conditions
Magnitude	Negligible	No measurable change from baseline conditions or natural variation on permafrost, terrain stability or landforms
	Low	Effect on one or more of the measurable parameters is detectable, but within the range of natural variation or baseline values; no change in permafrost condition, terrain stability or landforms
	Moderate	Effect on one or more of the measurable parameters is detectable and outside the range of natural variation or baseline values, but unlikely to change in permafrost condition, terrain stability or landforms
	High	Effect on one or more of the measurable parameters is detectable and outside the range of natural variation or baseline values, and hence a change in permafrost condition, terrain stability or landforms is evident
Geographic Extent	Site	Effect confined to specific features within the Project footprint
	Local	Effect confined to the LAA
	Regional	Effect extends beyond the LAA but within the RAA
Frequency	Once	Effect occurs once throughout the Project
	Sporadic	Effect occurs more than once, but at unpredictable intervals throughout the Project
	Regular	Effect occurs repeatedly at regular intervals throughout the Project
	Continuous	Effect occurs continuously throughout the Project
Duration	Short term	Changes in permafrost condition, terrain stability or landforms are no longer detectable at the end of construction
	Medium term	Changes in permafrost condition, terrain stability and landforms are no longer detectable at the end of final closure
	Long term	Changes in permafrost condition, terrain stability or landforms extend beyond the life of the Project
Reversibility	Reversible	Effect on permafrost condition, terrain stability or landforms is reversible over human lifetime
	Irreversible	Effect is not reversible, or will only reverse on geologic time line (i.e., thousands of years for terrain formation)

7.1.4 Standards or Thresholds for Determining Significance

A threshold is the level of change beyond which unacceptable adverse effects occur. In the case of terrain, well defined or accepted thresholds do not exist for the Canadian Arctic. The role of terrain within the terrestrial environment can be assessed either in terms of the area of coverage and its distribution within an area, or in terms of a specific function or value, such as preferred habitat. It is possible to measure the loss of surface and thus the loss of landforms, and its effect on habitat or other VECs.

In the absence of federal or territorial guidelines, a quantitative approach has been adopted to assess Project effects on terrain based on the best available information, previous experience with similar projects in the Canadian Arctic and best professional judgement to determine the significance of Project effects. Project effects on terrain are described quantitatively based on spatial coverage. Thresholds are defined using the proportion of lost surface or landform relative to the total area of the LAA. The following thresholds were selected based on the general knowledge of the Arctic terrestrial environment, professional judgment and the thresholds chosen in similar projects in Nunavut (e.g., High Lake Project). Residual effects are considered to be significant if the Project results in:

- more than 30% loss of the terrain surface
- more than 30% loss of the surface covered by common depositional landforms
- more than15% loss of the surface covered by any permafrost-sensitive landforms
- more than 15% loss of any uncommon landforms

A confidence rating is applied to the significance determination for residual effects on terrain. The rating considers the accuracy of the data used for baseline and application of analytical tools, an understanding of the effectiveness of the mitigation measures, and an understanding of known responses of the measurable parameters to potential Project effects. The confidence ratings are:

- Low – not confident in prediction, could vary considerably
- Moderate – confident in prediction, moderate variability
- High – confident in prediction, low variability

7.2 ASSESSMENT OF CHANGE IN PERMAFROST CONDITIONS AND TERRAIN STABILITY

7.2.1 Analytical Methods for Change in Permafrost Conditions and Terrain Stability

Two factors that determine change in permafrost are the ground temperature and the volume of ground-ice within the permafrost overburden. The ground temperature is influenced by several factors: air temperature, type or thickness of vegetation cover, organic soils insulation, snow cover, and terrain slope. These factors control the thawing and freezing of the active layer. The thickness of the active layer possesses a seasonal nature, which is influenced by additional factors such as the nature of the underlying soil and rock and human disturbance.

Site and vegetation clearing, potential change in terrain slope, modification of surface water and drainage patterns, changes in subsurface groundwater flow and any destructive activities such as blasting will likely result in changes in permafrost conditions and terrain stability. A map of thaw depth was developed in support of the effects assessment for permafrost conditions. This map focussed on the mine LAA. The map was developed based on thaw depth estimates from ground temperature measurements, as well as measurements taken using frost depth indicators in 19 geotechnical boreholes. The potential area of high ground-ice with thaw depth ranging from 2 to 3 m was delineated north of the Kiggavik mine and infrastructure area. Ground-ice conditions were described in the majority of the boreholes. Approximately 99 tests were performed to determine soil water (moisture) content. Details of the map, thaw depth analysis, grain size distribution analysis, soil density determination, ground-ice descriptions and water content analysis results can be found in Tier 3, Appendix 6A.

Road alignments were identified and an assessment was qualitatively completed to determine adverse effects to the permafrost layer as well as terrain stability associated with development of the different road options. An assessment based on the area affected by development of the preferred dock site facility was also completed.

7.2.2 Baseline Conditions for Change in Permafrost Conditions and Terrain Stability

The Kiggavik Project is located within the zone of continuous permafrost (NRCan 2007). Ground-ice content is likely less than 10% over most of the area (Brown et al.1998). This low ground-ice content occurs over most of the terrain, except for marine and localized fine-grained (high silt or clayey silt content) materials, which may contain more than 10% ground-ice. The mine LAA is characterized by relatively stable terrain conditions as it is dominated by flat lying or gently sloping terrain, and a rolling and hummocky topography with frequent bedrock outcrops.

The majority of the area near the Kiggavik mine site has a thaw depth of 1 to 2 m (see Tier 3, Appendix 6A). An area of potentially greater thaw depth (2 to 3 m) was delineated north of the site. No drilling data exists for the Sissons mine site regarding thaw depth; however, it is anticipated that the thaw depth at this location will be similar to the Kiggavik mine site given the close proximity of these areas.

7.2.3 Effect Mechanism and Linkages for Change in Permafrost Conditions and Terrain Stability

Construction and operation activities can cause surface and subsurface disturbance, which in turn can affect vegetation cover, organic soil insulation and frozen overburden materials. Removal of vegetation cover, organic soil insulation and snow cover generally leads to warming and thawing of the active layer and changes the shallow thermal regime and drainage condition. In thawing, the ice will disappear and, for existing overburden pressures, the soil skeleton must now adapt itself to a new equilibrium void ratio (Andersland and Ladanyi 2004). This further causes the active layer to deepen, and the new thaw zone may cause thaw settlement and eventually terrain instability. Thawing at a slow rate allows generated water to flow from the soil at about the same rate as melting occurs. Excess pore pressures will not be sustained, and settlement proceeds simultaneously with thawing. For faster thawing rates, excess pore pressure will be generated. These excess pore pressures will reduce shear strengths, creating potentially unstable terrain or slope conditions (Andersland and Ladanyi 2004). This will likely change the overall permafrost conditions and its distribution, and terrain stability, which can cause the loss or change in permafrost sensitive landforms and eventually a change in the abundance and distribution of landforms within the mine LAA.

Terrain instability associated with the disturbance of surficial material is generally confined to the development of shallow depth. This effect is generally associated with the disturbance of the active layer and subsequent thawing of ground-ice, and the over-steepening of existing slopes. Although the majority of the mine LAA is characterized by gentle slopes, there are localized areas of steeper terrain.

During the construction and operation phases of the Project, there is a high potential for ground disturbance of the permafrost, which may induce terrain instability in the higher relief areas. Terrain stability is serious in terms of safety and effects on normal mine operations. However, in terms of effects on the natural surficial materials and bedrock, only the mine component of the Project footprint will be affected. The proposed mine area is characterized by relatively plain and stable terrain conditions and an effect associated with relatively steep terrain is not expected.

Development of the proposed road options has the potential to impede surface water drainage. This could potentially result in pooling of water in areas adjacent to the road options, which could potentially destroy vegetation, as well as changing the properties of overburden materials, which form a surface insulation layer that protects the permafrost layer. This could potentially result in an increase in thaw depth into the permafrost layer.

7.2.4 Mitigation Measures and Project Design for Change in Permafrost Conditions and Terrain Stability

As the greatest potential effects of the Project on permafrost condition and terrain stability will occur in areas with low ground temperature, mitigation measures will be implemented to comply with regulations and guidelines applicable to permafrost areas in the Canadian Arctic, which provide objectives, principles and design criteria for planning, operation and remediation of projects.

Mitigation measures will be implemented in two ways: mitigation by design and discipline-specific mitigation. Mitigation by design encompasses those aspects of the Project design that will reduce effects to the permafrost and stability of terrain, and particularly to the surface area used by the Project to minimize footprint disturbance and to avoid permafrost sensitive and uncommon landforms. Some of the mitigation measures by design will include padding of surface horizons to maintain existing permafrost conditions, use of platforms for equipment to reduce any heat transfer into frozen ground and use of thermal stabilization methods (such as convection air embankment, heat drains, grass-covered embankments, snow fences, and reflecting surfaces), where feasible.

Discipline-specific mitigation will include the consideration of Project activities such as construction in permafrost-sensitive areas during the winter where feasible, restriction of vehicular traffic to the designated North Winter Road and North All-Season Road, maintenance of roads and monitoring of the North All-Season Road. Discipline-specific mitigation will minimize the exposure of permafrost to warmer temperatures, maintain the permafrost conditions and ensure the identification of signs of possible permafrost degradation.

Mitigation measures to reduce or eliminate Project effects on permafrost conditions and terrain stability include the following:

Permafrost Conditions:

- limit the Project footprint disturbance area
- sustain safe construction and operation practices within and adjacent to the Project footprint disturbance area
- use coarser materials for road construction to minimize frost effects
- manage drainage around infrastructure to reduce deep pools of water at the surface
- insulate infrastructure, where feasible
- implement proper construction and engineering design to consider the slope stabilization methods; for example, build foundations on bedrock not susceptible to frost heave to minimize thawing effect in permafrost sensitive areas

- avoid surface disturbance in high ground-ice areas to reduce potential for deepening the thaw depth and associated thaw settlement
- conduct additional site-specific field investigations to assess specific poorly drained areas and local variations in permafrost conditions (ground-ice content) prior to construction
- place culverts in areas crossed by the road options where surface drainage is apparent.

Terrain Stability:

- carry out a detailed geotechnical investigation before construction of mine infrastructure to collect data on surficial materials, drainage, slope, and permafrost and ground temperature (to aid in determining road alignment, along with facilitating post-construction monitoring of Project effects on terrain stability)
- avoid or minimize the amount of problematic terrain types (e.g., ground- ice rich, fine- to medium-textured materials on sloping topography) within the mine infrastructure area and along major road alignments
- consider the criteria for the design of roads for varying terrain types based on the findings and recommendations of the previous design work done on similar projects in the Arctic environments (as suggested in Tier 3, Appendix 2L)

The projected rate of climate warming and its effects will be taken into account in the design of all Project elements based on the most up-to-date findings and predictions. Prior to initiation of the construction phase, additional field investigations will be completed to assess specific poorly drained areas and local variations in permafrost and terrain conditions.

7.2.5 Project Residual Environmental Effects for Change in Permafrost Conditions and Terrain Stability

Mine LAA

Residual effects of the Project on permafrost conditions and terrain stability will be confined to the Kiggavik and Sissons mine sites. This effect will occur primarily during the construction phase, although operations activities will continue to change permafrost conditions and terrain stability. Key Project activities during operation include mining and stockpiling of ore, special waste and clean waste that will involve destructive activities such as blasting, loading and hauling. These operations activities can induce ground disturbance as well as cause changes in the shallow and deep thermal regime, which can eventually change permafrost conditions.

Physical loss or change in permafrost from the Project footprint may cause changes to terrain and its stability. Changes to the active layer and consequently the thaw depth can reduce terrain stability through thaw settlement, decrease in shear strengths, frost heave and slope stability.

The magnitude of changes in the permafrost thermal regime and potential thaw settlement is directly related to the nature and abundance of ground-ice and the type and severity of disturbance at the surface (Lawson 1986; Pullman et. al. 2007). The depth of the permafrost under climate change condition is expected to decrease from -220 m to -100 m (see Tier 3, Appendix 5J). Undisturbed ground surfaces (natural ground) will likely retain permafrost after a warming of 5°C over 100 years (see Tier 3, Appendix 5G).

Surface disturbance related to the removal of overburden materials will cause a change in permafrost conditions. About 803 ha (2.22%) of the mine LAA is predicted to be disturbed (Table 7.2-1). This includes about 645 ha (or 1.78% of the mine LAA) due to site clearing and topsoil stripping, and 158 ha (0.44% of the mine LAA) due to soil and vegetation burial.

With implementation of mitigation, residual effects on changes to permafrost and terrain stability are expected to be low in magnitude, site specific, long term, continuous, and reversible.

North All-Season Road LAA

The proposed North All-Season Road is expected to be 114 km and extend from the Kiggavik mine site to the preferred dock site facility on the north shore of Baker Lake. It will be a 24-m-wide gravel road built from rock materials from the quarry sites (fill method) placed on top of the existing terrain. By placing materials on top of the existing terrain, the surface insulation layer that protects the shallow permafrost layer is not disturbed; therefore, the potential for thawing of the permafrost layer at the road location is reduced, which also prevents any terrain stability issues. As well, any adverse environmental effect related to erosion that is influenced by thawing of the permafrost layer is also reduced.

The proposed road is designed and routed on higher ground as these areas tend to contain less ground-ice, fewer drainage areas to cross, are less prone to snow drifts, and generally contain more bedrock, as well as suitable quarry locations. Routing the proposed road on higher ground will reduce geotechnical issues and road fill required during construction. This will also reduce potential maintenance issues (e.g., snow drifts) throughout the life of the Project.

With implementation of mitigation measures, residual effects on changes to permafrost conditions and terrain stability caused by the proposed North All-Season Road are predicted to be low in magnitude and site specific in geographic extent. The residual effects will be long term in duration and continuous in frequency; however, all residual effects will be reversible.

Winter Road LAAs

Permafrost conditions and terrain stability are not anticipated to be affected by development of the winter road options. Granular fill will be added in localized areas to create a level travel surface over hummocky microtopography. Construction and operation of the winter road will occur during frozen ground conditions; therefore, adverse effects on permafrost conditions and terrain stability are anticipated to be negligible.

Table 7.2-1 Areas Affected by Construction Activities within the Mine LAA

Project Component	Vegetation, Organic Soil and Overburden Stripping	Vegetation and Organic Soil Burial	Area (ha)	Area (%)	Distance in the LAA (km)	Area (km^2)	Width (m)	Vegetation, Organic Soil and Overburden Stripping in the LAA (ha)	Vegetation and Organic Soil Burial in the LAA (ha)	Vegetation, Organic Soil and Overburden in the LAA (% of Total LAA)
Kiggavik Site										
Site Camp, Mill and Infrastructure	X		103	0.28				103		0.28
Ore stockpile	X		7	0.02				7		0.02
Mine Rock Stockpile Type III	X		13	0.04				13		0.04
Mine Rock Stockpile Type II (2 locations)	X		135	0.37				135		0.37
Overburden Stockpile	X		14	0.04				14		0.04
East Zone Pit	X		8	0.02				8		0.02
Centre Zone Pit	X		15	0.04				15		0.04
Main Zone Pit	X		39	0.11				39		0.11
Purpose Built Pit	X		3	0.01				3		0.01
Explosives and Magazine Area		X	2	0.01					2	0.01
Freshwater Diversion Channels	X		24	0.07				24		0.07
Pointer Lake Airstrip		X	36	0.10					36	0.10
Sissons Site										
Site Buildings and Infrastructure	X		64	0.18				64		0.18
Ore Stockpile	X		1	0.00				1		0.00
Mine Rock Stockpile Type III	X		12	0.03				12		0.03
Mine Rock Stockpile Type II	X		132	0.36				132		0.36
Overburden Stockpile	X		15	0.04				15		0.04
Andrew Lake Pit	X		44	0.12				44		0.12
Freshwater Diversion Channels	X		16	0.04				16		0.04
Roads and Other										
Access Road to Airstrip and Judge Sissons Lake		X			13	0.312	24		31.2	0.09
Kiggavik-Sissons Access Road		X			18	0.432	24		43.2	0.12
Access Road to Siamese Lake		X			9	0.216	24		21.6	0.06
Road/Effluent Pipe from Kiggavik and Sissons Sites to Judge Sissons Lake		X	24	0.07	10	0.24	24		24	0.07
Total			**707**	**1.95**		**1.2**		**645**	**158**	
Mine LAA (ha)	**Mine Site (ha)**	**% Removal**	**% Burial**	**% Total Disturbance**						
36,240.00	803.00	1.78	0.44	2.22						

Dock Site Options

Construction of the dock site facility at site option #1 (preferred option) is estimated to disturb approximately 25 ha. Alternative dock site options #2 and #3 are estimated to disturb approximately 29.4 ha and 19.9 ha, respectively.

No permafrost conditions were encountered in the boreholes drilled within the vicinity of the proposed dock site facilities, likely due to a thawing effect caused by Baker Lake. However, there is the potential for permafrost to occur at the dock site locations as they are located within the continuous permafrost zone (see Tier 3, Appendix 6A for further details). Overburden materials at the dock site facility will be removed and stored. Following removal of the overburden, a site pad will be constructed with a minimum thickness of 1.7 m to provide thermal protection to the underlying permafrost layer, while providing structural stability to the dock site facility.

The preferred dock site option is located in marine units located along the shorelines, as well as a combination of bedrock and glacial (till veneer) units' farther upland. Development of the dock site location will likely involve removal of the overburden down to bedrock materials to facilitate a stable foundation for the dock site facility.

With implementation of mitigation measures, residual effects on changes to permafrost and terrain stability caused by the proposed dock site facility are expected to be low in magnitude and site specific in geographic extent. The residual effects will be long term in duration and continuous in frequency; however, all residual effects will be reversible.

7.2.6 Determination of Significance for Change in Permafrost Conditions and Terrain Stability

The residual effect of changes in thaw depth and ground-ice conditions on permafrost conditions and terrain stability is predicted to be low in magnitude within the mine LAA, site specific, long term and continuous. However, these effects are expected to be reversible, and are not anticipated to affect the long-term conditions of permafrost and terrain stability within the mine LAA. Approximately 2.2% of the mine LAA will be disturbed, which is below the threshold value. The residual effects due to stripping and/or burial of vegetation, organic soil zone and underlying overburden materials will be confined within the Project footprint and are expected to be not significant. Change in surface drainage patterns and subsurface water flow will be within the Project footprint, and mitigation measures during the detailed design and all phases of the Project will reduce effects on permafrost conditions and terrain stability.

The residual effect of changes in permafrost condition and terrain stability within the road LAAs and the dock site facility is predicted to be low in magnitude, site specific, long term and continuous. However, these effects are expected to be reversible.

The mitigation measures for reducing effects on permafrost conditions and terrain stability are well accepted and practiced for construction and operation of mining projects in areas of continuous permafrost in Canadian Arctic. Total area affected by Project activities is low with respect to the total area of the mine LAA and road LAAs, which is based on the available baseline data and the Project description. Hence, the level of confidence in this prediction is rated as high. Confidence will be further improved through monitoring during Project construction and operation.

7.2.7 Compliance and Environmental Monitoring for Change in Permafrost Conditions and Terrain Stability

A monitoring system of permafrost and terrain stability will be established during all phases of the Project based on the historical study results and best professional judgement. The progression of thaw depth will be monitored within the Project activity areas. Potential change in moisture and ground-ice contents will also be monitored during the construction, operation, final closure and post-closure phases of the Project. As changes to terrain stability will occur mainly during the construction phase of the Project and the effects will be long term, especially when climate change implications are considered, an environmental monitoring program will be initiated at the start of the construction and will continue until closure and decommissioning of the Project. This program will include:

- establishment of a 'Thaw-Depth Monitoring System' at the Kiggavik and Sissons mine sites, and the North All-Season Road
- soil sampling to determine soil moisture and ground-ice contents of the active layer within the permafrost overburden
- routine visual field inspection of terrain slope conditions within the mine development and adjacent areas, and if necessary, installation of slope stability monitoring devices to measure slope movement
- annual monitoring of all roads, particularly areas identified as having a probability of instability

7.3 ASSESSMENT OF CHANGE IN LANDFORMS

Landforms that are influenced by permafrost and are sensitive to disturbance are termed permafrost sensitive landforms. The most common sensitive landforms in the mine LAA are thaw sensitive soils, which are common to continuous permafrost regions in the Canadian Arctic. Thaw sensitive soils contain at least a small amount of ground-ice, and are typically fine grained in texture with higher silt or clayey silt contents and have significantly low permeability. Effects to permafrost sensitive landforms are mainly related to change in the thermal regime of permafrost. The other types of landforms included in the assessment are common depositional landforms and uncommon landforms, which have ecological, traditional and cultural values (e.g., eskers).

7.3.1 Analytical Methods for Change in Landforms

To assess the effects of surface disturbance on various landforms, the Project footprint was overlain on a baseline map of surficial geology showing common depositional landforms. The area affected by the Project footprint for each landform type was calculated to determine total loss.

Major landforms were subdivided into depositional landform types (alluvium or outwash sediments, glaciofluvial, glacial till or moraine, glaciaomarine, organic and bedrock-related landforms) within the mine LAA, and a map of surficial deposits was developed showing those landforms. The percent coverage of depositional landforms was estimated in relation to the total area of the mine LAA.

Glacial landforms were identified based on the surficial geological conditions. The localized north-northwest-trending glacial landforms preserve evidence of regional ice flow. Glacial landforms around the proposed mill site in the mine LAA are dominated by hummocky, bouldery glacial till and scattered boulder till moraines with frequent bedrock outcrops and shattered bedrock features in isolated exposures and elongated.

No evidence of cryoturbation and patterning of ground associated with the development of permafrost sensitive landforms were identified within the mine LAA.

Three esker-related landforms have been identified within the mine LAA. However, they occupy a negligible area and are outside of the direct footprint of the Project components of the mine LAA.

A 500-m buffer centered over the proposed road alignments was used to identify the proportion of depositional landforms in the area to be a conservative assessment of landforms potentially affected by development of the road options.

7.3.2 Baseline Conditions for Change in Landforms

The percent coverage area of each depositional type of landforms with respect to the total area of the mine LAA is assessed and is provided below.

Total area of the mine LAA = 36,240 ha

Alluvial (or outwash sediments) landforms = 3,786 ha (approximately 10% of the LAA)

Glaciofluvial landforms = 200 ha (less than 1% of the LAA)

Morainal (glacial till) landforms = 30,356 ha (approximately 84% of the LAA)

Glaciomarine landforms = 108 ha (less than 1% of the LAA)

Bedrock landforms= 1,790 ha (approximately 5% of the LAA)

Baseline data of landforms located within the 500-m buffered area of the North All-Season Road are presented in Table 7.3-1.

Table 7.3-1 Landform Areas Located along the Proposed North All-Season Road

Depositional Landforms	Code	North All-Season Road Coverage Area	
		(ha)	(%)
Alluvial	Ao	263.66	0.51
Marine	Mr	154.16	0.30
Glaciofluvial	Go	55.47	0.11
Glacial	Tb	4585.89	8.81
	Tv		
Bedrock	R1	2199.28	4.23
	R2		
Total		7258.46	13.95
NOTE: Total area of the North All-Season Road LAA is 52,032 ha.			

7.3.3 Effect Mechanisms and Linkages for Change in Landforms

Construction and operation activities including excavation, placement of structural foundations, road construction, airstrip construction, pads and quarrying will cause surface disturbances that can lead to a change or direct loss of surface materials due to stripping or burial of the surficial deposits associated with landforms. This can further lead to a change in the quantity of common landforms and the loss or change in uncommon landforms such as eskers.

Construction and operation activities will also change the shallow thermal regime, surface drainage pattern and subsurface water system due to the disturbance of surface materials and their removal or burial, which will lead to changes in permafrost conditions. Due to changes in permafrost conditions, loss of or change in permafrost sensitive landforms can occur, resulting in a change in abundance and distribution of such landforms. No significant permafrost sensitive and uncommon landforms have been identified within the Project footprint areas and hence the Project is not expected to affect such landforms.

7.3.4 Mitigation Measures and Project Design for Change in Landforms

The most effective mitigation measures for potential Project effects on landforms will take place during the Project design. Construction best practices will also be used to identify and mitigate potential effects on permafrost sensitive and uncommon landforms.

Mitigation measures will include:

- considering the local and regional climatic conditions, and the presence and expected changes to permafrost terrain
- avoiding uncommon landforms like eskers, wetlands and shoreline areas, as well as steep terrain (where possible) during the design phase of Project
- minimizing cut width or disturbance through eskers, wetlands and shoreline areas
- reducing the use of glaciofluvial landforms during mine infrastructure construction
- applying best management practices and best professional judgement (e.g., planning of proper culvert location and construction and maintenance of roads susceptible to excessive groundwater seepage)

7.3.5 Project Residual Environmental Effects for Change in Landforms

7.3.5.1 Mine LAA

Residual effects on landforms will be confined to the Project footprint and will occur primarily during construction and, to a lesser extent, during operation and final closure of the Project. Project effects on landforms will likely occur at the local scale, due primarily to surface disturbances that affect the stability, abundance and distribution of various common landforms within the mine LAA. Project activities such as excavation, the construction of the site camp, mill and infrastructure will involve the stripping or burial of surficial deposits, which will affect various landforms. Surface disturbance may also be required to level the camp and mill sites, infrastructure and roads, storage area, and excavate the proposed mines and quarries. Gravel or fill pads will be needed to build foundations, the airstrip and other Project facilities such as overburden, ore and mine rock stockpiles. Any surface disturbed by stripping, levelling or burial of surficial materials will result in a loss of landforms.

Table 7.3-2 presents the total area of each landform type that will be affected by surface disturbances associated with the Project. It should be noted that the calculated surface covered by each landform type does not include the surface covered by water. The total surface covered by water encompasses 6,154 ha of the mine LAA.

Table 7.3-2 Project Disturbances to Common Depositional Landforms within the Mine LAA

Common Depositional Landforms	CODE	LAA Baseline Coverage Area*			Project Disturbance Footprint*		
		Area of Landform (ha)		% of Total Mine LAA	Disturbed Area (ha)	Total Mine LAA (%)	Landform Disturbed within the Mine LAA (%)
Alluvial	AO	3,786	3,786	10.45%	22.15	0.061	0.59
Glaciofluvial	Gk	40	200	0.55%	0.00	0.00	0.00
	Go	160					
Glaciomarine (Marine/Littoral)	Mr	108	108	0.30%	0.48	0.001	0.44
Bedrock	R1	758	1,790	4.94%	68.27	0.188	3.81
	R2	1,032					
Morainal (Glacial Till)	Tb	22,918	30,356	83.76%	720.43	1.988	2.37
	Th	205					
	Tv	7,233					
Total		36,240	36,240	100.00%	811.33	2.239	

NOTE:
* The surface covered by water has not been included in the calculations of surface percent coverage of landforms in the mine LAA.

About 22 ha (0.59%) of the total surface area of the mine LAA covered by alluvial landforms (3,786 ha) will be lost, or 0.06% of the total area of the mine LAA. Consequently, Project effects on alluvial landforms will be negligible.

Glaciofluvial landforms are significant in terms of the soils and vegetation they support, as well as their sensitivity to permafrost conditions and the stability of terrain due to any external disturbance. This type of landform supports warmer soils and valued vegetation communities. Disturbance to this type of landforms may have effects on other glacial features such as glaciofluvial plains and thermokarst plains. However, no glaciofluvial landforms will be disturbed and no effects on this type of landform are predicted.

Less than 1 ha (0.44%) of the total surface area of the mine LAA covered by glaciomarine landforms (108 ha) will be lost as a result of surface disturbances, or 0.001% of the total area of mine LAA. Consequently, Project effects on glaciomarine landforms will be negligible.

About 68 ha (3.81%) of the total surface area of the mine LAA covered by bedrock landforms (1,790 ha) will be lost due to the Project, or 0.19% of the total area of mine LAA. About 720 ha (2.37%) of the total surface area of the mine LAA covered by glacial till or morainal landforms (30,356 ha) will be lost as a result surface disturbances, or 1.99% of the total area of mine LAA. Consequently, Project effects on this type of landforms expected to be low.

It is estimated that the Project footprint will cover 2.24% (811 ha) of the mine LAA. There will likely be burial of surface landforms by construction materials within the proposed roads (access roads to airstrip, Judge Sissons Lake, Siamese Lake, Kiggavik-Sissons Access Road, and a small segment of the North All-Season Road) and hence all road disturbance footprints on surface landforms within the mine LAA are included in the calculations.

New landforms will be created by the development of the waste rock piles. Two waste rock piles will be created at each of the Kiggavik and Sissons mine sites, creating new landforms of about 148 ha and 144 ha, respectively. These landforms will be an elevated topographic feature on the landscape.

Physical loss or change in common landforms is expected within the footprint of the mines and infrastructure. However, it is anticipated that Project activities will likely result in only limited changes to landforms. By implementing effective mitigation measures during the design, construction, operation and final closure and post closure phases of the Project, changes to landforms are anticipated to be low in magnitude, site-specific, long term and will likely occur once, and irreversible.

7.3.5.2 North All-Season Road

Residual effects on landforms will be confined to the road footprint and will occur primarily during construction. Construction of the road will involve the burial of common landforms. A summary of the areas covered by common landforms and crossed by the proposed road option as well as the proportion of the total area of the road options anticipated to be buried is provided in Table 7.3-3. The total surface area of the North All-Season Road LAA encompasses approximately 273 ha.

The estimated surface areas covered by alluvial, glaciofluvial, glaciomarine, bedrock and morainal (glacial till) landforms that are expected to be buried by the proposed road will comprise 6.65 ha (0.01%), 0.35 ha (less than 0.01%), 6.60 ha (0.01%), 65.76 ha (0.13%) and 148.02 ha (0.28%) of the total area of the North All-Season Road LAA, respectively. Although 46.34 ha (0.09%) of the North All-Season Road LAA lacks data, similar types of common landforms are predicted to exist in those areas with no data.

Physical loss in common landforms is expected as a result of the construction within the footprint of the road. However, it is anticipated that the road construction will likely result in only limited changes to landforms. By implementing effective mitigation measures during the design, construction, operation and final closure and post closure phases of the Project, changes to landforms are anticipated to be low in magnitude, site-specific, long term and will likely occur once, and irreversible.

Table 7.3-3 Common Depositional Landforms Affected within the North All-Season Road LAA

Common Depositional Landforms	Code	Project Disturbance Footprint	
		Disturbed Area (ha)	% of Landform Disturbed within the North All-Season Road LAA
Alluvial	AO	6.65	0.01
Glaciofluvial	Gk	0.35	0.00
	Go		
Glaciomarine (Marine/Littoral)	Mr	6.60	0.01
Bedrock	R1	65.76	0.13
	R2		
	R1/Mr*		
Morainal (Glacial Till)	Tb	148.02	0.28
	Th		
	Tv		
Data Gap	No Code**	46.34	0.09
Total		273.72	0.53

NOTES:
Littoral sediments (Mr) in combination with bedrock (R1) are assumed *to be bedrock landforms.*
** *No data exits.*
Total area of the North All-Season Road LAA is 52,032 ha.

7.3.5.3 Winter Roads

The winter road options are not anticipated to affect landforms as the routes selected focussed on level terrain that will be frozen during road construction and operation. Therefore, any effects to landforms by the winter roads will be negligible.

7.3.5.4 Dock Site Options

The preferred dock site option (i.e., option #1) will affect an area of about 25 ha. This area is characterized by gradually slopping gravelly/sandy beach deposits, which grade more steeply up a bedrock slope covered by a veneer of terraced marine sand and gravel. No uncommon landforms will be affected by development of the dock site option. With implementation of mitigation measures, residual effects on changes to landforms by the proposed dock site facility are expected to be low in magnitude, site specific, long term, will likely occur once, and irreversible.

7.3.6 Determination of Significance for Change in Landforms

The extent of changes or loss of common landforms due to the Project is predicted to be not significant within the mine LAA. Approximately 2.2% of the total surface coverage of common depositional landforms within the mine LAA will be disturbed, which is significantly below the thresholds. No glaciofluvial landforms, permafrost sensitive landforms and uncommon landforms will be disturbed. Changes to landforms within the road LAAs and the dock site facility are also predicted to be not significant because areas affected are below threshold values.

The level of confidence in this prediction is considered high, as the mitigation measures are well accepted and practiced and have been shown to be effective for construction and operation of mining projects in areas of continuous permafrost in Canadian Arctic. Changes to landforms due to Project activities are assessed to be low with respect to the total surface coverage within the mine LAA, which is based on the area affected by the Project. The level of confidence will be further improved through monitoring that will be undertaken during Project construction and operation.

7.3.7 Compliance and Environmental Monitoring for Change in Landforms

A monitoring system for changes to landforms will be established during all phases of the Project based on the baseline study results and professional judgment. The progression of loss or change in landforms due to Project activities will be monitored within the Project development and adjacent areas.

Potential change in slope, drainage pattern, subsurface water system or soil will also be monitored during the construction and operation of the Project, which will reduce or eliminate effects to landforms. An environmental monitoring program will include routine field observation of landforms within the mine development and adjacent areas.

During the detailed design phase of the Project, disturbance within the mine and infrastructure footprint will be limited by avoiding potentially problematic landforms, where feasible. Prior to construction, additional field investigations will be conducted to visually inspect and assess all types of existing landforms.

7.4 CUMULATIVE EFFECTS ANALYSIS FOR TERRAIN

7.4.1 Screening for Cumulative Environmental Effects

As Project residual effects on landforms are not expected to extend beyond the LAA or overlap with any other existing or future projects or activities, no cumulative effects on terrain are anticipated to occur. As a result, the cumulative effect of changes in terrain is not considered further in this assessment.

7.5 SUMMARY OF RESIDUAL ENVIRONMENTAL EFFECTS ON TERRAIN

7.5.1 Project Residual Environmental Effects

7.5.1.1 Permafrost Conditions and Terrain Stability

The mine LAA covers a total area of 36,240 ha, which excludes surface area covered by water. Surface disturbance of vegetation cover, organic soil insulation and permafrost overburden materials is predicted to affect about 803 ha (2.2%) of the LAA. This will be caused by vegetation clearing and soil stripping (1.8% of the LAA) and burial (0.4% of the LAA).

- The residual effects of stripping and/or burial of vegetation, organic soil zone and underlying overburden materials on permafrost conditions and terrain stability will be confined within the Project footprint, low in magnitude, site specific, long term, continuous over the life of the Project, and reversible. Overall, residual environmental effects of the Project on permafrost conditions and terrain stability are predicted to be not significant.
- A summary of the residual environmental effects for permafrost conditions and terrain stability is provided in Table 7.5-1.

7.5.1.2 Landforms

The estimated surface areas covered by alluvial, glaciomarine, bedrock and morainal (glacial till) landforms that are expected to be disturbed by the Project total 0.06%, 0.001%, 0.19% and 1.99% of the total area of mine LAA (i.e. 36,240 ha), respectively. Overall, the total area disturbed by stripping and burial of landforms is estimated to be 811 ha (2.2%) of the mine LAA.

Residual environmental effects of changes in landforms are expected to be low in magnitude, site specific, long term, will likely occur once, and irreversible. Overall, residual effects of the Project on permafrost conditions and terrain stability are predicted to be not significant. A summary of the residual environmental effects for landforms is provided in Table 7.5-1.

The residual effects presented considered Project-related effects on an individual basis. While these residual effects may be low in magnitude and vary in duration and frequency, the combination of the Project-related effects and their influence on the residual effects could have additional changes to terrain. These combined interactions and potential changes in residual effects are complex and difficult to understand and analyze, and no clear interaction mechanism has been found in the literature. Based on professional judgment, the combination of Project-related effects and the subsequent residual effects for terrain are anticipated to be no greater that the residual effects on an individual basis as these effects were assessed on a conservative basis. Therefore, the combined Project-related effects on terrain are predicted to be not significant.

Table 7.5-1 Summary of Project Residual Environmental Effects for Change in Terrain

Project Phase	Mitigation/ Compensation Measures	Residual Environmental Effect (Y/N)	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
				Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in Permafrost Conditions and Terrain Stability: Stripping and/or burial of vegetation, organic soil zone, and underlying overburden materials; change in slope, change in surface drainage patterns and subsurface flow, and blasting will affect thaw depth and ground-ice content.													
Construction	Minimize the Project footprint disturbance area	Y	A	L	S	LT	C	R	D	N	N/A	H	Establishment of ground temperature and thaw depth monitoring system around the mine and mine affected areas; and along the embankment of roads; routine visual field observation of terrain slopes
	Salvage vegetation, soils and overburden materials												
	Confine activities within the boundaries of Project work area												
Operation	Avoid surface disturbance in ground-ice rich areas												Monitoring of soil moisture and ground-ice content
Final closure													Monitoring of surface and subsurface groundwater system
Post closure	Not required												
Change in Landforms: Stripping and/or burial of surficial materials will affect common depositional landforms and their abundance and distribution													
Construction	Minimize the Project footprint disturbance area	Y	A	L	S	LT	O	I	D	N	N/A	H	Routine field observation of the progression of possible loss or change in landforms within the mine development and adjacent areas due to Project activities
	Avoid or reduce the use of glaciofluvial deposits												
	Salvage surficial materials												
Operation	Avoid surface disturbance in soft and problematic areas												
Final closure													

Table 7.5-1 Summary of Project Residual Environmental Effects for Change in Terrain (cont'd)

KEY

Direction:

P Positive: improvement relative to baseline conditions

N Neutral: no change relative to baseline

A Adverse: reduction relative to baseline

Magnitude:

N Negligible: No measurable change from baseline conditions or natural variation on permafrost, terrain stability or landforms.

L Low: Effect on one or more of the measurable parameters is detectable, but within the range of natural variation or baseline values; no change in permafrost condition, terrain stability or landforms.

M Moderate: Effect on one or more of the measurable parameters is detectable and outside the range of natural variation or baseline values, but unlikely to change in permafrost condition, terrain stability or landforms.

H High: Effect on one or more of the measurable parameters is detectable and outside the range of natural variation or baseline values, and hence a change in permafrost condition, terrain stability or landforms is evident.

Geographic Extent:

S Site specific: (i.e., within the Project Footprint)

L Local (i.e., within the LAA)

R Regional (i.e., extends beyond the LAA but within the RAA)

Duration:

ST Short term: change no longer detectable at the end of construction.

MT Medium term: change no longer detectable at the end of final closure.

LT Long term: change extends beyond the life of the Project.

Frequency:

O Once: occurs once throughout the Project

S Sporadically: occurs more than once, but at unpredictable intervals.

R Regularly: occurs repeatedly at regular intervals.

C Continuous: occurs continuously throughout the Project.

Reversibility:

R Reversible: effect reversible over human lifetime

I Irreversible: effect not reversible, but reversible over geologic time scale

Environmental Context:

D Disturbed

N Not Disturbed

Significance:

S Significant

N Not Significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood:

Of a significant effect occurring

N/A Not Applicable

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Cumulative Effects

Y Potential for effect to interact with other past, present or foreseeable projects or activities

N Effect will not or is not likely to interact with other past, present or foreseeable projects or activities

7.5.2 Cumulative Effects

The Kiggavik Project is not expected to contribute to cumulative effects on terrain in the RAA.

7.5.3 Effects of Climate Change on Terrain

Long-term climate change could have an effect on terrain in the Project area depending on the degree and rate of warming. Increasing mean annual air temperature could lead to warmer weather during the summer months, which could increase the mean annual ground surface temperature. With anticipated warming conditions, the existing thermal regime and permafrost conditions may change, thereby increasing the probability of terrain instabilities due to solifluction, erosion, etc. Warming of permafrost soils and rock may result in greater availability of water within the system, and change the internal physical characteristics and engineering properties of surficial materials.

Thermal modelling results for the long-term climate scenario over 2,000 years in the Kiggavik Project area show that if the mean annual ground surface temperature rises, the change in permafrost depth will be evident at the base but not at the surface (see Tier 3, Appendix 5J). Another model predicted a cooling trend will occur over the next 50 years (see Tier 3, Appendix 4D). Undisturbed ground surfaces (natural ground) will likely retain permafrost after an assumed climate warming trend of 5°C in the mean annual ground surface temperature over the next 100 years, and permafrost will likely develop and be maintained within the waste rock stockpiles and the covered TMF under the current climatic conditions (see Tier 3, Appendix 5G). Natural ground permafrost degradation with climate warming is anticipated to occur over 2000 years for the two assumed warming trends (trend 1: from -7°C to -2°C, and trend 2: from -6°C to -1°C) and the predicted permafrost depths will be -100 m and -45 m relative to the initial permafrost depth of -220 m for the warming trend 1 and trend 2, respectively (see Tier 3, Appendix 5J).

The potential effects of climate change on terrain in the short and long term may include the following:

- permafrost melting
- terrain instability

7.5.3.1 Permafrost Melting

The short-term effect of climate change is anticipated to occur due to surface disturbance activities during the construction and operation and may affect the vegetation cover and organic soil insulation within the mine LAA as vegetation cover, organic soils and permafrost overburden material will be stripped or buried. Upon removal or burial of these layers, change in shallow thermal regime may occur. Deepening of thaw depth, ground softening, and thaw settlement in local scale may occur as a result of both Project activities and climate change.

The long-term effect on permafrost may be anticipated due to climate change. Changes to thaw depth (active layer thickness) may influence the stability of terrain through thaw settlement, frost heave potential and shear strength.

7.5.3.2 Terrain Instability

In the absence of mitigation measures, predicted increases in permafrost temperature and thaw depth due to climate warming are expected to cause settling, and create engineering challenges to terrain and slope stability.

It is anticipated that Project activities will result in minor changes to permafrost conditions and terrain stability within the Project footprint of the mine LAA. By implementing mitigation practices and using permafrost design features with due consideration of climate change in Arctic, changes to permafrost and terrain stability are anticipated to be minor relative to the baseline condition. Therefore, the cumulative effects of climate change to change in terrain conditions are predicted to be negligible.

7.6 SUMMARY OF MITIGATION MEASURES FOR TERRAIN

Effective mitigation strategies for effects on terrain require identification of problematic terrain types that may be susceptible to either terrain instability or thaw settlement or are considered to be significant and sensitive landforms. By identifying specific locations of problematic areas, effective mitigation measures can be tailored to address site-specific conditions.

Detailed mitigation measures will vary depending on local conditions and Project activities. Best construction and project management practices coupled with recent engineering advances, especially in permafrost engineering, will be implemented to address any issues with changes in permafrost conditions, and terrain stability. Issues related to the surface disturbance to any problematic and challenging landforms will be best addressed by proper citing of Project facilities and associated infrastructure.

Design mitigation measures will include minimizing Project disturbance footprint and the number of drainage areas affected by the Project components and activities, and avoiding surface disturbance in high ground-ice areas and problematic terrain and landforms to reduce potential for deepening the thaw depth and associated thaw settlement and terrain stability. Discipline-specific mitigation will include the consideration of Project activities such as construction in permafrost sensitive areas during the winter time where feasible, controlled vehicular traffic along roads, planning of proper culvert location and construction and maintenance of roads susceptible to excessive groundwater seepage.

Additional mitigation measures will include:

- sustaining safe construction and operation practices within and adjacent to the Project footprint
- using coarser materials for road construction to minimize frost effects
- managing drainage around infrastructure to reduce deep pools of water at the surface
- insulating infrastructure where feasible
- avoiding problematic terrain associated with high ground-ice content
- avoiding fine- to medium-textured materials on sloping topography within the mine infrastructure area and along major road alignments
- avoiding uncommon landforms like eskers, wetlands and shoreline areas
- reducing cut width or disturbance through eskers, wetlands and shoreline areas
- reducing the use of glaciofluvial landforms during mine infrastructure construction

Consideration and implementation of effective engineering design criteria and construction best practices with due consideration of the projected rate of climate warming based on the findings and recommendations of the previous design work done on similar projects in the Arctic environments will be one of the key mitigation measures.

Supplementary engineering field investigations prior to construction of mine infrastructure will help to reduce or eliminate potential Project effects on terrain. Additional site-specific field investigations will be conducted to assess specific poorly drained areas and drainage condition, local variations in permafrost conditions (ground-ice content), terrain slope, and ground temperature prior to construction of mine infrastructure and roads.

7.7 SUMMARY OF COMPLIANCE AND ENVIRONMENTAL MONITORING FOR TERRAIN

While the implementation of mitigation strategies is critical to reducing any effects on terrain, it is equally as important to complete regular and routine monitoring to ensure that effects on the terrain are minimized and to identify where new mitigation strategies may be required. Monitoring will begin upon construction and will continue through the duration of the Project.

A key consideration in design of the monitoring programs is that the environment is expected to change, independent of the Project, as a result of climate change. For the most part, visual monitoring will suffice as it will be important to visually observe any changes (e.g., accelerated solifluction, groundwater seepage, erosion, etc.). In some cases, especially on steeper slopes, slope monitoring devices will be used for the duration of the Project. Similarly, thermistors will

be installed at key sites to determine and monitor the rate of change in ground temperature. Special devices will also be installed to record maximum thaw penetration and maximum ground-surface movement at thaw depth monitoring sites. While such devices are not required extensively throughout the Project footprint, a number of permanent monitoring plots will be established at the outset of the Project to monitor any effects of climate change and hence the overall change in the natural landscape. Laboratory analysis of soil samples will be conducted, which will help to determine geotechnical parameters such as total moisture content, frozen bulk density and ground-ice content. These parameters will be used to calculate thaw strains, which are used to determine the thaw settlement resulting from the simulated increase in thaw depth at the each sampling site.

8 EFFECTS ASSESSMENT FOR SOILS

8.1 SCOPE OF THE ASSESSMENT FOR SOILS

8.1.1 Project-Environment Interactions and Effects

Project activities during the construction, operation and final closure phases have the potential to affect the quality and quantity of soils within the RAA. Key issues related to effects on soil include:

- deterioration of soil quality due to air emissions, including dust deposition, during all phases of the Project
- soil loss and deterioration caused by topsoil stripping, soil burial, erosion, admixing, and compaction during construction activities

Key Project activities that could affect soil quality and quantity are outlined in Table 8.1-1.

Table 8.1-1 Project–Environment Interactions and Effects on Soils

Project Component	Project Activities	Environmental Effect	
		Change in Soil Quality	Change in Soil Quantity
Construction			
In-water Construction	Construct freshwater diversions and site drainage containment systems (dykes, berms, collection ponds)	0	2
	Construct in-water/shoreline structures	0	2
On-land Construction	Site clearing and pad construction (blasting, earth-moving, loading, hauling, dumping, crushing)	2	2
	Road and airstrip construction	2	2
	Agreggate sourcing	0	2
Supporting Activities	Industrial machinery operation	2	0
	Power generation	2	0
Operation			
Mining	Mining ore (blasting, loading, hauling)	2	0
	Ore stockpiling	2	0
	Mining special waste (blasting, loading, hauling)	2	0
	Special waste stockpiling	2	0
	Mining clean waste (blasting, loading, hauling)	2	0
	Clean rock stockpiling	2	0

Table 8.1-1 Project–Environment Interactions and Effects on Soils (cont'd)

Project Component	Project Activities	Environmental Effects	
		Change in Soil Quality	Change in Soil Quantity
Operation (cont'd)			
Milling	Transfer ore to mill	2	0
	Crushing and grinding	2	0
Waste Management	Incineration and handling of burnables	2	0
General Services	Generation of power	2	0
Transportation	Truck transportation	2	0
Final Closure			
General	Industrial machinery operation	2	0
On-land Decommissioning	Remove site pads (blasting, earth-moving, loading, hauling, dumping)	2	2
NOTE: See definitions of rankings in Section 5.6			

8.1.2 Measurable Parameters

Table 8.1-2 lists the measurable parameters used to assess Project effects on soil quality and soil quantity and the rationale for their selection.

Table 8.1-2 Measurable Parameters for Soils

VEC	Environmental Effect	Measurable Parameters	Rationale
Soils	Change in soil quality	Soil chemistry (i.e., soil acidification from air emissions, fugitive dust deposition) Area (km^2) of soil compaction, admixing and erosion	Potential acid input (PAI), as well as changes in pH and metals caused by dust deposition and nutrient transport in soils can influence vegetation occurrence Soil compaction, admixing, erosion could alter soil quality, which in turn could influence vegetation occurrence
	Change in soil quantity	Area (km^2) to have topsoil stripped or soil lost as a result of erosion, movement or burial	Soil removal or burial could alter soil quantity, which in turn could influence vegetation occurrence

8.1.3 Residual Environmental Effects Criteria for Soils

Residual effects on soils are characterized quantitatively and qualitatively using the following attributes: direction, magnitude, geographic extent, duration, frequency, and reversibility. Table 8.1-3 provides definitions for these attributes.

Table 8.1-3 Residual Environmental Effects Criteria for Soils

Attribute	Rating	Definition
Direction	Positive	Improvement in soil quality or soil quantity relative to baseline conditions.
	Neutral	No change in soil quality or soil quantity relative to baseline conditions.
	Adverse	Reduction in soil quality or soil quantity relative to baseline conditions.
Magnitude	Negligible	No affect from baseline conditions or natural variation on soil quality or soil quantity.
	Low	Effect on one or more of the measurable parameters is detectable, but within range of natural variation or baseline values; no change in soil quality or quantity.
	Moderate	Effect on one or more of the measurable parameters is detectable and outside the range of natural variation or baseline values, but is unlikely to change soil quality or quantity and reclamation end land use objectives will still be met.
	High	Effect on one or more of the measurable parameters is detectable, outside the range of natural variation or baseline values, and changes soil quality or quantity will prevent reclaiming the landscape to meet end land use goals.
Geographic Extent	Site	Effect confined to specific features within Project footprint.
	Local	Effect confined to the LAA.
	Regional	Effect extends beyond the LAA but within the RAA.
Frequency	Once	Effect occurs once.
	Sporadic	Effect occurs more than once, but at unpredictable intervals.
	Regularly	Effect occurs repeatedly at regular intervals.
	Continuous	Effect occurs continuously throughout the Project.
Duration	Short term	Changes in soil quality or soil quantity are no longer detectable at the end of construction.
	Medium term	Changes in soil quality or soil quantity are no longer detectable at the end of final closure.
	Long term	Changes in soil quality or soil quantity extend beyond the life of the Project.
Reversibility	Reversible	Effect on soils is reversible over human scale lifetime.
	Irreversible	Effect is not reversible, or will only reverse on geologic time line (e.g. thousands of years for soil formation).
Environmental Context	Disturbed	Area has been substantially disturbed previously by human development, or human development is still present.
	Not Disturbed	Area has not been disturbed by human development.

8.1.4 Standards or Thresholds for Determining Significance

8.1.4.1 Soil Quality

The significance of Project residual effects on soil quality is determined by the extent of changes in chemical levels in soil in comparison to CCME soil quality guidelines (CCME 2009). These values are used to evaluate changes in soil concentrations from emissions of metals; no standards exist for radionuclides. Additional information is provided in the Ecological and Human Health Risk Assessment (i.e., Tier 3, Appendix 8A).

Threshold values developed by the Clean Air Strategic Alliance (CASA, 1999) and the World Health Organization (2000) for potential acid input (PAI) are used to determine the significance of Project residual effects of acid deposition on soil quality. For sensitive soils, the critical load threshold for PAI (i.e., will not cause long-term ecosystem change) is 0.25 keq/ha/year. Exceedances above the critical load threshold do not mean environmental damage will occur; rather, there is the potential for an effect from PAI on the environment if deposition above the critical load is sustained over many years (CASA 1999).

The significance of changes in soil quality due to admixing, compaction, and erosion is determined during monitoring of construction activities, and mitigation measures to reduce or prevent these environmental effects are continuously evaluated to determine their effectiveness. Therefore, the significance of these environmental effects on soil quality is assessed based on a qualitative description of the Project residual effects.

8.1.4.2 Soil Quantity

Project effects to soil quantity are described quantitatively based on the number of hectares affected, as well as the proportion of the area disturbed within the respective LAAs.

A confidence rating is applied to the significance determination for residual effects on soils. The rating considers the accuracy of the data used for baseline and application of analytical tools, an understanding of the effectiveness of mitigation measures, and an understanding of known responses of the measurable parameters to potential Project effects. The confidence ratings are:

- Low – not confident in prediction, could vary considerably
- Moderate – confident in prediction, moderate variability
- High – confident in prediction, low variability

8.2 ASSESSMENT OF CHANGE IN SOIL QUALITY

8.2.1 Analytical Methods for Change in Soil Quality

Changes in soil quality were assessed based on air quality modelling (see Tier 3, Appendix 4B) to estimate PAIs generated by the Project at the proposed mine sites, as well as dust deposition (metals and radionuclides) generated by Project activities. Adverse effects on soil quality due to changes in the concentration of the Constituents of Potential Concern (COPC) in soil were evaluated based on comparisons to CCME criteria and changes relative to baseline conditions. The COPC included in this assessment include uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium and zinc. Detailed modelling of the concentration of these COPCs in dust is discussed in the Atmospheric Environment (Tier 2, Volume 4). The results of the air quality assessment are the basis for estimating changes in soil concentrations. A simple deposition model was used for estimating changes in soil concentrations, and the details are discussed in the Ecological and Human Health Risk Assessment (i.e., Tier 3, Appendix 8A).

8.2.2 Baseline Conditions for Change in Soil Quality

Soil pH was found to be weakly acid to neutral (average 6.1), and ranges from moderately acid (4.8) to slightly basic (7.8) from the samples taken. A comparison of metal and radionuclide concentrations in soil samples to the CCME (2009) levels for industrial land use areas found one sample to exceed recommended arsenic levels, one sample to exceeded nickel levels, two samples to exceed copper levels, and at least one sample to exceed selenium levels.

Soil texture ranged from silty clay (located in a well-drained area) to loamy sand, with the majority of soil samples exhibiting a sandy clay loam texture. Coarse fragments were found in all soil samples, with the majority of fragments found within the B and C horizons. Roots were commonly observed within most soil samples.

8.2.3 Effect Mechanisms and Linkages for Change in Soil Quality

8.2.3.1 Soil Acidification

Soils acidification involves the introduction of acidifying compounds to soils. Soils are considered a primary receptor of acid deposition (CASA 1999). A main pathway for introducing acidifying compounds (i.e., sulphur dioxide [SO_2] and nitrogen dioxide [NO_2]) to soils is through air emissions, where these compounds are transformed and deposited as acids onto soils. The deposited acids are measured as PAI.

Air emissions created by the Project through the burning of fossil fuels have the potential to cause soil acidification. Project activities that will introduce large amounts of air emissions containing acids include the milling process (i.e., acid plant), power generation from diesel generators, and the use of industrial machinery and equipment. Soil acidification resulting from long-term deposition of acidifying substances can result in lower soil pH, a decrease in base saturation and increase in aluminum bioavailability. The results of these changes in soil chemical properties have been shown to negatively affect nutrient cycling and decomposition processes by changing microbial community populations and soil function, and often result in aluminum toxicity to vegetation (Holowaychuk and Fessenden 1987).

8.2.3.2 Dust Deposition

Dust deposition can potentially change the pH and nutrient regime of soils (Auerbach et al. 1997; Myers-Smith et al. 2006; Walker and Everett 1987). Project activities that will generate dust include on-land construction, mining, milling, general services, transportation, and on-land decommissioning. Dust deposition has been shown to cause soil pH to become more basic in a tundra environment (Myers-Smith et al. 2006), which in turn causes a change in the vegetation communities that occur on these soils (Auerbach et al. 1997; Myers-Smith et al. 2006). Changes in the soils' nutrient regimes are also prevalent with the introduction of nitrogen to nutrient-poor soils through dust deposition. An increase in nitrogen to the soils allows plants that have an affinity towards nitrogen to proliferate, such as grasses. Other analytes (e.g., COPC) that become airborne through dust particles can be transported and deposited away from their source.

8.2.3.3 Soil Admixing

Soil admixing involves the mixing of soil horizons. Admixing of the soil layers can affect soil quality by causing changes in soil texture and structure, as well as diluting organic matter and organic carbon, which can negatively influence microbiological activities (Wick et al. 2009). In environments containing continuous permafrost, soil admixing is a naturally occurring phenomenon through cryoturbation (i.e., the mixing of materials among the soil horizons due to freezing and thawing). The presence of patterned ground on the landscape indicates where cryoturbation has occurred. Avoiding further soil admixing from human-caused disturbance is essential for preserving the growth medium layer for reclamation purposes.

8.2.3.4 Soil Compaction

Soil compaction is the process by which a stress applied to a soil causes the soil to become denser as air is displaced from the pores between the soil grains. Soil compaction influences structure, drainage, porosity, and susceptibility to erosion, which affects soil quality. Soil compaction caused by movement of heavy equipment and repeated movement of lighter equipment, as well as placement of heavy materials on top of the soils can break down the soil structure. Compacted soils reduce the ability for vegetation to establish and proliferate.

8.2.3.5 Soil Erosion

Soil erosion involves the wearing of exposed soils due to climatic events, such as wind, precipitation or water flow over a surface. Soil quality can be reduced due to loss of organic materials and soil particles containing valuable nutrients required for vegetation. Soils stored in overburden piles will be susceptible to erosion due to their exposure to climatic events. A loss of soil from erosion events will likely affect revegetation efforts following replacement of soils from the overburden pile over the disturbed areas.

8.2.4 Mitigation Measures and Project Design for Change in Soil Quality

The following mitigation measures and Project design features will be implemented to reduce Project effects on soil quality:

- Industrial machinery and equipment (including the diesel-powered generators) will meet the federal air emission standards.
- Low sulphur diesel fuel will be used to reduce emissions associated with diesel fuel combustion.
- Scrubbers will be installed on exhaust stacks to remove particulates, acid mist and excess SO_2 from air emissions prior to discharge.
- Stripped topsoil will be kept separate from subsoils stored at the overburden pile location to prevent soil admixing, as well as loss of the growth medium layer that will be used for reclamation purposes.
- Stripped topsoils will also be well-segregated from the ore piles and the Type III mine rock stockpiles to prevent soil contamination.
- Stripped topsoil and subsoil materials stored in the overburden pile location will be scanned to ensure no radiation contamination prior to use during site reclamation.
- Frozen or wet soils removed during site preparation will be stored within dry soil materials of the same nature (i.e., topsoil, subsoil) to prevent potential migration and subsequent admixing with other soil or waste rock piles.
- Freshwater diversion channels will be constructed to divert surface drainage around the Project footprint to prevent on-site erosion, as well as to prevent potential contamination of surface drainage.
- Riprap armouring overlying a geotextile will be placed on the channel bottom and side slopes of the diversion channels to mitigate potential erosion of the channel.
- If required, erosion control structures (e.g., sediment breakers, wattles) may be used within the diversion channels following initial excavation to reduce the amount of soil erosion by flowing water until vegetation has established or a geotextile liner is placed within the channel.

- Culverts will be installed where the proposed North All-Season Road crosses natural drainage patterns to facilitate water movement.
- Site pads will be sloped towards the run-off ponds to prevent any contaminated materials from migrating off-site due to surface drainage.
- If required, temporary erosion control structures (e.g., silt fences) will be placed on the downslope side of the Project footprint to capture and filter sediment-laden runoff during construction.
- If necessary, a substance such as a soil tackifier may be applied to the overburden piles to prevent erosion of soils.
- During final closure, areas ready for reclamation will be scarified to loosen compacted soils to better facilitate seed germination.
- Soft spots on the winter road will be identified and avoided by vehicular traffic. Rig matting may also be used to prevent rutting and other disturbances to soils where the winter road's integrity is compromised.
- During open pit mining, blasting patterns will be used to control the dispersion of materials as well as dust.
- Where possible, blasting may also be avoided on days where dust dispersion outside of the Project footprint is anticipated to be excessive due to the prevailing winds speeds.
- Dust suppression will occur continuously during the Project in dust-prone areas by spraying water from a tanker truck affixed with either a spray nozzle or spray bar.
- If water spraying is not effective in preventing dust occurrence, an adaptive management strategy focusing on additional dust suppression techniques will be investigated, such as using a dust suppressant identified in the GN (2002) guidelines.
- Speed limits around the mine site and along all roads will be strictly adhered to, to reduce airborne dust from vehicular and other equipment traffic.

8.2.5 Project Residual Environmental Effects for Change in Soil Quality

No residual effects on soil quality are predicted to occur outside of the LAAs. A description of the predicted residual effects within each LAA is provided below.

8.2.5.1 Mine LAA

Air quality modelling predicted changes in COPC concentrations in soils within the LAA below the CCME (2009) Soil Quality Guidelines (Table 8.2-1; see Tier 3, Appendix 8A for further details), and will be localized in geographic extent. Any change in soil quality due to changes in COPC concentrations are predicted to be low in magnitude, and occur continuous during the construction and operation phases of the Project. Although changes in soil quality are anticipated to be long term, effects of increased concentrations of COPC in soils will be reversible over time following decommissioning of the Project.

It is predicted that approximately 81 ha outside of the Project footprint of the Kiggavik mine site, will likely be exposed to PAI levels is excess of the critical load threshold (i.e., greater than 0.25 keq/ha/year). This represents approximately 0.2% of the mine LAA. PAI levels at the Sissons mine site are not predicted to exceed the threshold value. There may be a difference in PAI sensitivity among soil classes based on soil quantity, texture and presence of organic matter. However, the scale of the PAI assessment model (1^{o} latitude by 1^{o} longitude cells) found in Alberta Environment (AENV 2008) does not reflect this level of detail. The residual effect from PAI on soils is anticipated to be low in magnitude and localized in geographic extent. Changes to soil quality due to PAI are anticipated to occur continuously during the construction and operation phases of the Project and are anticipated to occur over the medium term, as Project activities contributing to PAI would cease to occur at the end of operation. The effects are anticipated to be reversible.

Soil compaction due to construction activities will be confined to the Project footprint, and will occur predominately in sandy clay loam soils that contain coarse fragments within the B and C horizons. Sandy soils are less prone to compaction than silty or clay soils, and soils with a high content of coarse fragments are less susceptible to compaction than stone-free soils (Archibald et al. 1997). While compaction may occur on soils that have higher clay content, the occurrence of these types of soils appears to be low based on baseline studies (see Tier 3, Appendix 6B, Attachment G). Therefore, the residual effects of soil compaction on soils is predicted to be low, site specific in geographic extent, will likely occur sporadically during the Project, but will be medium term in duration and reversible.

The residual effects from soil admixing and soil erosion will likely be kept within the confines of the Project footprint. With implementation of the mitigation measures described in Section 8.2.4, effects from soil admixing and soil erosion on soil quality are anticipated to be negligible.

Table 8.2-1 Maximum Predicted Mean and 95th Percentile COPC Concentrations in Soils

COPC	Units	SQG		Baseline	Predicted Soil Concentrations							
					Kiggavik Camp		LAA*		RAA*		Baker Lake	
		Ag.	Res/Prk		Mean	95th	Mean	95th	Mean	95th	Mean	95th
U	µg/g	23	23	1.2	1.3	1.4	1.2	1.3	1.2	1.3	1.2	1.3
Th-230	Bq/g	-	-	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Pb-210	Bq/g	-	-	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ra-226	Bq/g	-	-	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Po-210	Bq/g	-	-	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
As	µg/g	12	12	3.8	3.8	4.2	3.8	4.2	3.8	4.2	3.8	4.2
Cd	µg/g	1.4	10	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Co	µg/g	40	50	4.0	4.0	4.4	4.0	4.4	4.0	4.4	4.0	4.4
Cu	µg/g	63	63	8.9	9.0	9.9	9.0	9.9	9.0	9.9	9.0	9.9
Pb	µg/g	70	140	13.7	13.7	15.1	13.7	15.1	13.7	15.1	13.7	15.1
Mo	µg/g	5	10	1.8	1.8	2.0	1.8	2.0	1.8	2.0	1.8	2.0
Ni	µg/g	50	50	12.4	12.4	13.7	12.4	13.7	12.4	13.7	12.4	13.7
Se	µg/g	1	1	0.8	0.8	0.9	0.8	0.9	0.8	0.9	0.8	0.9
Zn	µg/g	200	200	14.2	14.2	15.7	14.2	15.7	14.2	15.7	14.2	15.7

NOTES:

Soil Quality Guidelines (SQG) for Agricultural and Residential/Parkland from CCME (1999)

* The LAA and RAA boundaries used in the Ecological and Human Health Risk Assessment report differ from the Terrestrial Assessment boundaries. See Tier 3, Appendix 8A, Section 3 for boundary clarification.

8.2.5.2 Road LAAs

Air quality modelling for COPC concentrations in soils was not completed for the road LAAs; however, modelling is completed for the RAA, which includes the road LAAs. Predictions from this modelling indicate that COPC concentrations within the RAA will be below the CCME (2009) Soil Quality Guidelines (Table 8.2-1; see Tier 3, Appendix 8A for further details). Therefore, any changes in soil quality (as a result of an increase in COPCs concentrations within the road LAAs) are anticipated to be low in magnitude, and localized in geographic extent. Changes in COPC concentrations are predicted to occur regularly throughout the life of the Project, and the effects on soil quality are anticipated to be long term but reversible.

As vehicle traffic along the winter roads will be occurring during frozen ground conditions, soil compaction is not anticipated, except in localized spots where rutting may occur in places where granular material was not used for creating a level travel surface. Soil compaction along the proposed North All-Season Road would be restricted to the confines of the road. The residual effects of soil compaction along the North All-Season Road is predicted to be low, site specific in geographic extent, occur regularly during the Project, be medium term in duration and reversible.

Soil admixing will not occur during development and operation of the proposed roads, as materials used to develop the roads will be placed on top of the existing and undisturbed tundra. Therefore, no residual effects are anticipated.

Soil erosion is not anticipated at the winter road locations as use will occur during frozen ground conditions and climatic events (e.g., precipitation, wind) will not be able to initiate erosion of soil. Proper culvert placement and installation along the proposed North All-Season Road will prevent soil erosion from surface drainage.

8.2.5.3 Dock Site Options

Air quality modelling for COPC concentrations in soils was not completed at the proposed dock sites; however, modelling results are provided for the community of Baker Lake, which is located near the sites. Results of the modelling indicate that COPC concentrations will be below the CCME (2009) Soil Quality Guidelines at the community of Baker Lake (Table 8.2-1; see Tier 3, Appendix 8A for further details). Therefore, the residual effects of COPCs on soil quality is anticipated to be low in magnitude, and localized in geographic extent. Any changes to soil quality due to changes in COPC concentrations are predicted to occur regularly throughout the duration of the Project and the effects are anticipated to be long term and reversible.

Soil compaction caused by vehicular movement during the loading and unloading of the barge at the proposed dock site will likely occur but will be limited to the confines of the site pad located at the dock site location. The residual effects of soil compaction at the dock facility is

predicted to be low, site specific in geographic extent, occur regularly during the Project, medium term in duration and reversible.

The residual effects from soil admixing and soil erosion will likely be kept within the confines of the dock site. It is anticipated that with implementation of the mitigation measures effects of soil admixing and soil erosion on soil quality at the dock facility to be negligible.

8.2.6 Determination of Significance for Change in Soil Quality

Given the low predicted levels of COPC concentrations and PAI and the confined nature of effects from soil admixing, compaction and erosion within the Project footprint, changes in soil quality as a result of the Project are predicted to be not significant. Overall, confidence in the predicted changes to soil quality is considered high for the following reasons.

- The effectiveness of mitigation measures related to soil quality is well understood, and the recommended practices are typical for mining operations.
- Project-related effects on soil admixing, compaction, and erosion is well understood, and mitigation measures to reduce or prevent Project-related effects are well known and effective.
- Conservative estimates of emissions sources from Project activities were used to determine the potential effects on soil acidification and changes in the COPCs outside the Project footprint.

Prediction confidence will be further enhanced through a pre-development monitoring program that includes dust and air emission monitoring.

8.2.7 Compliance and Environmental Monitoring for Change in Soil Quality

Compliance and environmental monitoring for potential changes in soil quality will include the following:

- chemical analyses of soil samples from permanent sample plots
- air emissions and dust deposition monitoring
- comparison of chemical analysis results from soils to air emissions and dust deposition results, as well as to baseline values and CCME guidelines
- routine checks of overburden piles for signs of erosion; implementation of mitigation measures if issues are identified

- monitoring of the winter road for structural integrity to avoid rutting or damage to underlying soils, with appropriate mitigation measures implemented in areas of concern
- monitoring of the North All-Season Road for structural integrity, effectiveness of dust suppression techniques, as well as effectiveness of culverts for allowing surface drainage while preventing soil scouring.

8.3 ASSESSMENT OF CHANGE IN SOIL QUANTITY

8.3.1 Analytical Methods for Change in Soil Quantity

Changes in soil quantity were assessed based on the maximum predicted area to be developed for the Project. The type of change to soil quantity varies based on the effect mechanism. Some of the effect mechanisms were quantitatively assessed based on predicted disturbances to soils, while other effect mechanisms were addressed qualitatively as the predicted disturbances cannot be quantified.

8.3.2 Baseline Conditions for Change in Soil Quantity

Topsoil depths are shallower in areas where bedrock outcrops occur, while topsoil depths are deeper in areas with a lower landscape position that is conducive to accumulating organic matter. Soils classified as either a Brunisolic Turbic Cryosol or Brunisolic Static Cryosol have shallower topsoil depths, while Organic Cryosols and Histic Static Cryosols contain deeper topsoil depths. The topsoil layer, or active growth medium layer used by vegetation, was determined to range from 3 cm to 31 cm in depth.

8.3.3 Effect Mechanisms and Linkages for Change in Soil Quantity

A number of different effect mechanisms can contribute to change in soils quantity during Project development. A summary of the effect mechanisms identified, as well as how the Project would influence change in soil quantity are described below.

8.3.3.1 Topsoil Stripping

Topsoil stripping involves the removal of the growth medium layer from a development area. The purpose of topsoil stripping is to conserve the growth medium layer for future reclamation purposes. Topsoil stripping will likely occur at the Kiggavik and Sissons mine sites, but will not occur during construction of the airstrip and the Kiggavik-Sissons access road. Topsoil stripping will also likely occur at the proposed dock site facility. All stripped topsoil will be stored in the overburden pile location, separate from any stored subsoils, to be used for reclamation purposes

8.3.3.2 Soil Erosion

Soil quantity can be reduced due to loss of finer particles and organic materials from bulk soil. Soils disturbed during construction of the Project footprint and the quarry sites, as well as soils stored in the overburden piles will be susceptible to erosion due to their exposure to climatic events. Loss of soil from erosion would likely affect reclamation activities associated with soil placement and vegetation occurrence.

8.3.3.3 Soil Movement

Soil movement involves the transport of disturbed soils from one location to another. The movement of soils during construction activities can inadvertently cause soil loss, most noticeably with topsoil. This effect mechanism is most evident when stripped soils are transported over a long distance by pushing the soil materials, usually with a grader or bulldozer. When pushing the stripped soils, portions of the stripped materials can inadvertently be lost in small depressions within the construction area. As the soil transfer distance increases, the amount of soil lost during soil movement can increase substantially.

8.3.3.4 Soil Burial

Soil burial is the loss of soil materials due to the placement of other materials on top of the existing soils. The effects of soil burial are most pronounced with topsoil, due to the loss of the active growth layer. Topsoil will not be salvaged for some components of the Project; rather, materials will be deposited on top of the existing soils and vegetation in an effort to prevent thawing of the permafrost layer. As such, the soils and vegetation will be buried. Areas where soil burial is anticipated include the Kiggavik-Sissons access road, the North All-Season Road, the airstrip, and any maintenance roads (e.g., road that parallels the effluent pipes to Judge Sissons Lake). Soil burial will also likely occur on the winter road in upland areas where granular material is used to create a level surface.

8.3.4 Mitigation Measures and Project Design for Change in Soil Quantity

The following mitigation measures and Project design features will be implemented to reduce Project effects on soil quantity:

- Construction activities may be postponed during large precipitation events to prevent excessive disturbance to vegetation and soils due to wet working conditions.
- Before commencing construction activities, a construction plan for topsoil stripping will be developed based on the topography and terrain features at the proposed mine sites and dock facility.

- Temporary overburden piles may be required in areas where terrain features or topography prevent pushing stripped materials to the overburden pile without causing substantial loss of stripped materials. In these instances, stripped materials will be transported from the temporary overburden piles in either a buggy scraper or dump truck to the final overburden pile location.
- Stripped topsoil will be kept separate from subsoils stored at the overburden pile location to prevent soil admixing, as well as loss of the growth medium layer that will be used for reclamation purposes.
- Freshwater diversion channels will be constructed to divert surface drainage around the Project footprint to prevent on-site erosion, as well as to prevent potential contamination of surface drainage.
- Riprap armouring overlying a geotextile will be placed on the channel bottom and side slopes of the diversion channels to mitigate potential erosion of the channel.
- If required, erosion control structures (e.g., sediment breakers, wattles) may be used within the diversion channels following initial excavation to reduce the amount of soil erosion by flowing water until vegetation has established or a geotextile liner is placed within the channel.
- Culverts will be installed where the proposed North All-Season Road crosses natural drainage patterns to facilitate water movement.
- If required, temporary erosion control structures (e.g., silt fences) will be placed on the downslope side of the Project footprint to capture and filter sediment-laden runoff during construction.
- If necessary, a substance such as a soil tackifier may be applied to the overburden piles to prevent erosion of soils.
- Soil burial during development of the roads and airstrip will be confined to the boundaries established from the detailed design for these components.

8.3.5 Project Residual Effects for Change in Soil Quantity

No residual effects on soil quantity are predicted to occur outside of the LAAs. A description of the predicted residual effects within each LAA is provided below.

8.3.5.1 Mine LAA

Approximately 803 ha will be disturbed by the Kiggavik and Sissons mine sites, which represents approximately 1.8% of the mine LAA. Of that area, approximately 645 ha will be affected by topsoil stripping, and approximately 158 ha will be affected by soil burial. The residual effects from soil movement and soil erosion on soil quantity are anticipated to be negligible with implementation of the mitigation measures identified in Section 8.3.4.

Changes in soil quantity are predicted to be low in magnitude and site specific in geographic extent, and will occur once during the construction phase. Residual effects on soil quantity will occur over the medium term at locations where soil stripping occurs, as stripped soils will be replaced during reclamation activities. However, effects of soil quantity due to soil burial will be longer term, as the development of new soil will need to occur on top of materials used to bury existing soils (e.g., airstrip).

8.3.5.2 Road LAAs

The road widths for the road options are expected to be 12 m wide for the winter roads, and 24 m wide for the North All-Season Road. For the winter roads, a conservative estimate of the entire portion of the winter road located within the uplands was used to predict the amount of soil burial, even though it is anticipated that only 50% of the upland portion of the winter road options will require granular fill for creating a level road surface (exact locations of granular material placement will be determined during the detailed design stage). Therefore, the predicted amount of soil burial due to winter road construction is considered conservative. A summary of the areas crossed by the proposed road options in relation to the amount of upland area, as well as the proportion of the total area of the road options anticipated to be buried is provided in Table 8.3-1. The proportion of the road LAAs affected by soil burial will be no greater than 0.2%.

Table 8.3-1 Areas Crossed by Proposed Road Options

Road Option	Total Distance	Total Area	Upland (anticipated soil burial)			Water		
	km	ha	km	ha	Proportion of Total Area (%)	km	ha	Proportion of Total Area (%)
South Winter Road	107	128.4	58	69.6	54.2	49	58.8	45.8
North Winter Road	119	142.8	35	42	29.4	84	100.8	70.6
North All-Season Road[1]	114	273.6	114	273.6	100.0	0	0	0.0

NOTES:
[1] Small portions of the North All-Season Road crosses water; however, these areas will contain bridges and will not be affected by granular fill.

Topsoil stripping and soil movement will likely occur at site-specific locations to facilitate vehicular travel over steep terrain along the proposed access roads. Soil erosion due to scouring by surface water at a culvert outflow location may also occur; however, the effects will likely only occur until removal of the culvert during final closure. With implementation of mitigation measures, residual effects from these activities are expected to be negligible.

The overall residual effects of road development on soil quantity are anticipated to be low in magnitude (i.e., 0.2% or less of the road area affected) and site specific in geographic extent (i.e., confined to the road footprint), and will occur once during the construction phase. The duration of residual effects on soil quantity will vary depending on the effect mechanism. Effects from soil movement on soil quantity will cease following completion of construction activities, and therefore will be short term. However, soil erosion due to water flow at culvert outflow locations could potentially occur until culvert removal and the replacement of topsoil from stripped areas during final closure, resulting in more medium term effects on soil quantity. In areas where soil burial occurs, recovery of soil quantity is expected to occur over the long term as natural development of new soil occurs on top of materials used to build the roads and airstrip. Further details regarding final closure of the Project can be found in the Preliminary Decommissioning Plan (i.e., see Tier 3, Appendix 2R).

8.3.5.3 Dock Site Options

Topsoil will be stripped and stored in an overburden pile at the dock facility. Construction of the dock facility at site option #1 (preferred option) is estimated to disturb approximately 25 ha. Alternative dock site options #2 and #3 are estimated to disturb approximately 29.4 ha and 19.9 ha, respectively. The areas disturbed by the dock site options represent less than 0.1% of the South Winter Road and North All-Season Road LAAs. Therefore, the residual effects associated with dock facility development on soil quantity are anticipated to be negligible.

8.3.5.4 Project Development Option Combinations

As described in the Project Description (Tier 2, Volume 2), a winter road will be constructed to support both the construction and operation phases of the Project. The North All-Season Road with a cable-ferry crossing the Thelon River has also been included as a viable option. As such, a comparison of the changes in soil quantity for the different Project development options was completed. A summary of the residual effects on soil quantity for the preferred Project development option combinations is provided below. The entire portion of the uplands located along the winter road options is used to determine the amount of soil buried. However, only 50% of the upland portion of the winter road options will require granular fill for creating a level road surface (exact locations of granular material placement will be determined during the detailed design stage). The residual effects on soil quantity for the alternate development option combinations are not anticipated to be substantially different from the preferred development option combinations.

South Winter Road and Dock Site Option #1 with the Mine Sites

Approximately 931.4 ha will be disturbed as a result of this development option combination, which represents less than 1% of the combined LAAs. Of the area affected, approximately 645 ha (69%) within the Kiggavik and Sissons mine sites will have the topsoil stripped and stored for reclamation purposes. Approximately 286.4 ha (31%) will be buried along the access roads and airstrip.

South Winter Road, North All-Season Road, and Dock Site Option #1 with the Mine Sites

The addition of the North All-Season Road would result in an additional 273.6 ha of disturbed area for a total area of about 1,205 ha, which represents less than 1% of the combined LAAs. The amount of area disturbed by soil burial would increase to approximately 560 ha (or 47% of the combined area) with the inclusion of the North All-Season Road. No additional topsoil stripping would be required for the North All-Season Road; therefore, the total area disturbed by topsoil stripping would be 645 ha (or 53% of the combined LAAs).

8.3.6 Determination of Significance for Change in Soil Quantity

Given the small amount of area disturbed under either development option (< 1% of the combined LAAs), any change in soil quantity as a result of construction and operation of the mine sites, access road and dock facility is predicted to be not significant. Overall, the confidence in this prediction is considered high for the following reasons.

- The effectiveness of mitigation measures related to soil quantity are well understood and the recommended practices are typical for construction activities associated with mining operations.
- Assessment of total soil losses (topsoil salvage vs. burial) associated with the Project are based on the Project Description (Tier 2, Volume 2) and are therefore considered to be accurate predictions.

Prediction confidence will be improved through the presence of an on-site environmental monitor during topsoil stripping and storage activities, as well as road construction.

8.3.7 Compliance and Environmental Monitoring for Change in Soil Quantity

Compliance and environmental monitoring for potential changes in soil quantity will include the following:

- An environmental monitor will likely be on-site during the construction phase to assist AREVA personnel and contractors with mitigation strategies to reduce the effects of the Project on soil quantity, such as topsoil stripping, soil storage, and soil erosion on disturbed areas.
- Dust deposition monitoring will occur throughout the duration of the Project to identify and mitigate potential effects.

8.4 CUMULATIVE EFFECTS ANALYSIS FOR SOILS

Project activities could contribute to changes in soil quality and quantity within the Kiggavik area as a result of air emissions, dust generation, site clearing and installation of Project components. Although residual Project effects on soils are expected to be of low magnitude and very localized, they could act cumulatively with that of other projects and activities occurring in the RAA at present and in the foreseeable future.

8.4.1 Screening for Cumulative Environmental Effects

Of the potential future projects and activities identified in the Project Inclusion List (Tier 1, Volume 1), only the Meadowbank dock site facility has the potential to interact with the Project. The Meadowbank dock facility is located approximately 1 km from the preferred dock site (Option #1). Both construction and operation activities at the Project dock facility could overlap temporally with operation of the Meadowbank dock and potentially cause cumulative effects on soil quality as a result of increased air emissions.

An air quality assessment was completed as part of the Atmospheric Environment (Tier 2, Volume 4) to determine potential cumulative effects from the combined operations of the Meadowbank and Kiggavik dock and storage facilities. Result of the modelling predicted exceedances of the 1-hour and 24-hour threshold values for ambient NO_2 concentrations during periods when both facilities are operating simultaneously. The exceedances are predicted to occur approximately 1 % of the time annually and are expected to be localized. While this NO_2 deposition could result in a decrease in soil quality, this would represent only a fraction of the ambient NO_2 concentrations, which are unlikely to cause a detectable change in soil quality.

One existing project was identified within the RAA consisting of the Meadowbank dock site facility. An air quality assessment was completed in the Atmospheric Environment (Tier 2, Volume 4) to determine potential effects from combined operations of the Meadowbank dock site facility and the preferred AREVA dock site facility (i.e., option #1). A residual cumulative effect was predicted at the 1-hour and 24-hour increments due to exceedances in threshold values associated with NO_2 concentrations in the air, while assuming both dock sites operating simultaneously. The exceedances are predicted to occur approximately 1% of the time, annually. However, the amount of NO_2 that would be deposited on the landscape would be a fraction of the concentration in the air; thus, no residual effects on soils are anticipated.

No past or existing projects were identified within the RAA. However, exploration activities are currently occurring near the proposed Project (Tanqueray option, Ukaliq, Schultz Lake, St. Tropez Claims, Judge Sissons, and Kiggavik S. exploration sites). As such, these activities are considered as part of the Base Case, and have been addressed in the context of current baseline conditions for soils.

None of the exploration sites located within the RAA are involved in the regulatory process, or have made a public announcement to seek regulatory approval. The effects of these exploration activities on soils are likely to be localized to the exploration site, and are not anticipated to overlap with the residual effects from the Kiggavik Project. As well, no other projects or developments are known to occur and no future projects are anticipated within the LAA and RAA boundary. As the Project effects are not expected to extend beyond the LAA or overlap with any other projects, no cumulative effects on soils are anticipated. As a result, the cumulative effect of changes in soil quality and quantity is not considered further in this assessment.

8.5 SUMMARY OF PROJECT RESIDUAL ENVIRONMENTAL EFFECTS ON SOILS

8.5.1 Project Residual Environmental Effects

The residual effects of changes in soil quantity and soil quality caused by the Project are predicted to be not significant (Table 8.5-1). For soil quality, changes in concentrations of COPC in soils within all of the LAAs were predicted to be below the CCME (2009) Soil Quality Guidelines. The residual effects caused by soil admixing, compaction and erosion are anticipated to be negligible with the implementation of effective mitigation measures The estimated total area outside of the Project footprint that has the potential to be exposed to PAI values of greater than 0.25 keq/ha/year is approximately 81 ha, which represents approximately 0.2% of the mine LAA. Because of the small area predicted to be affected by PAI, the residual effects are anticipated to be negligible.

Depending on the Project development option selected, changes in soil quantity are predicted to occur within an area of between 953 ha and 1,212 ha, both of which represent less than 1% of the combined LAAs. Of this total, about 645 ha will be disturbed by topsoil stripping and an additional 208 ha to 567 ha will be disturbed from soil burial.

Table 8.5-1 Summary of Project Residual Environmental Effects on Soils

Project Phase	Mitigation/ Compensation Measures	Residual Environmental Effect (Y/N)	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
				Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in soil quality: Air emissions from Project components will affect soil quality.													
Construction	• All industrial machinery and equipment (including the diesel-powered generators) will meet federal air emission standards	Y	A	L	L	LT	C	R	ND	N	NA	H	Monitoring of air emissions from static emissions sources associated with the Project (e.g., acid plant).
Operation	• Use of low sulphur diesel fuel.												Monitoring of soil permanent sampling plots located around the mine sites and access roads for changes in soil quality.
Final Closure Post Closure	• Scrubbers installed on mill stacks to remove particulates and contaminants before discharge into the atmosphere.												
Change in soil quality: Dust created by Project activities will affect soil quality.													
Construction Operation	• Avoid blasting on days when winds are excessive.	Y	A	L	L	LT	C	R	ND	N	N/A	H	Dust deposition monitoring around the mine sites as well as the access roads.
Final Closure Post Closure	• Dust suppression by spraying water or other approved substance on travel area.												

Table 8.5-1 Summary of Project Residual Environmental Effects on Soils (cont'd)

Project Phase	Mitigation/ Compensation Measures	Residual Environmental Effect (Y/N)	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
				Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in soil quality: Soil compaction due to vehicular movement will affect soil quality.													
Construction Operation Final Closure	• Vehicular travel on the winter road will occur during frozen ground conditions, thereby preventing soil compaction. • Scarification of areas to be reclaimed during final closure will loosen compacted soils.	Y	A	L	S	MT	C	R	ND	N	N/A	H	During reclamation and revegetation, identify areas where soil compaction is evident and implement mitigation measures to de-compact soils, allowing better seed germination conditions.
Change in soil quantity: Site clearing during Project construction will affect soil quantity.													
Construction	• Activities confined within the work area boundaries. • Topsoil stripping and salvage.	Y	A	L	S	MT	O	R	ND	N	N/A	H	Environmental monitor on-site during construction.
Change in soil quantity: Soil burial due to the placement of materials on undisturbed areas during Project construction will affect soil quantity.													
Construction	• Activities confined within the work area boundaries.	Y	A	L	S	LT	O	R	ND	N	N/A	H	Environmental monitor on-site during construction.

Table 8.5-1 Summary of Project Residual Environmental Effects on Soils (cont'd)

Project Phase	Mitigation/ Compensation Measures	Residual Environmental Effect (Y/N)	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
				Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in soil quality: Soil compaction due to vehicular movement will affect soil quality.													
Change in soil quantity: Soil movement during Project construction will affect soil quantity.													
Construction	• Construction plan during topsoil stripping and salvage. • Using equipment to transport soils to overburden pile rather than pushing soils.	Y	A	L	S	ST	O	R	ND	N	N/A	H	Environmental monitor on-site during construction.
Change in soil quantity: Soil erosion until site stabilization, or vegetation establishment and proliferation on disturbed areas will affect soil quantity.													
Construction Operation Final Closure Post Closure	• Erosion control structures to prevent migration of materials off-site.	Y	A	L	S	MT	S	R	ND	N	N/A	H	Monitoring of site, overburden piles, and culverts along access roads for erosion potential and occurrence.

Table 8.5-1 Summary of Project Residual Environmental Effects on Soils (cont'd)

KEY

Direction:

P Positive
N Neutral
A Adverse

Magnitude:

N Negligible: no measurable change in soil quality or soil quantity
L Low: effect is detectable but no measurable change in soil quality or soil quantity.
M Moderate: effect is detectable and outside the range of natural variation, but is unlikely to change soil quality or soil quantity.
H High: a change in either soil quantity or soil quality will occur, preventing reclaiming the landscape to meet end land use goals.

Geographic Extent:

S Site specific: (i.e., within Project Footprint)
L Local (i.e., within the LAA)
R Regional (i.e., extends beyond the LAA but within the RAA)

Duration:

ST Short term: change no longer detectable at the end of construction
MT Medium term: change no longer detectable at the end of final closure
LT Long term: change extends beyond the life of the Project

Frequency:

O Once.
S Sporadically: occurs more than once, but at unpredictable intervals
R Regularly: occurs repeatedly at regular intervals
C Continuous: occurs continuously throughout the Project

Reversibility:

R Reversible
I Irreversible

Environmental Context:

D Disturbed: area has been substantially disturbed previously by human development, or human development is still present.
N Not Disturbed: area has not been disturbed by human activity.
N/A Not Applicable

Significance:

S Significant
N Not Significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence
M Moderate level of confidence
H High level of confidence

Likelihood:

Of a significant effect occurring

N/A Not Applicable
L Low probability of occurrence
M Medium probability of occurrence
H High probability of occurrence

Cumulative Effects

Y Potential for effect to interact with other past, present or foreseeable projects or activities
N Effect will not or is not likely to interact with other past, present or foreseeable projects or activities

The residual effects considered each effect alone (e.g., PAI alone, changes in COPC concentrations alone). Combined interactions and potential changes in residual effects are complex and difficult to understand, and no clear interaction mechanism has been found in the literature. Based on professional judgment, the combination of Project-related effects and the subsequent residual effects for soils are anticipated to be no greater that the residual effects on for each effect alone. These isolated effects are assessed on a conservative basis. Therefore, the combined Project-related effects on soils are predicted to be not significant.

8.5.2 Residual Cumulative Environmental Effects

The Kiggavik Project is not expected to contribute to cumulative effects on soils in the RAA.

8.5.3 Effects of Climate Change on Soils

Climate change will likely have the most pronounced effect on soil quantity as a result of increased soil erosion due to changes in temperature, precipitation, and wind. Soil susceptibility to erosion would likely increase with increases in temperature, decreases in precipitation, and increases in duration and magnitude of wind events. Soils exposed by the Project (e.g., overburden pile) would likely be most susceptible to soil loss.

8.6 SUMMARY OF MITIGATION MEASURES FOR SOILS

Soil Quality

Air emissions that could cause soil acidification as well as changes in COPC concentrations within soils will occur throughout the duration of the Project. To reduce the potential for soil acidification and changes in COPC concentrations, emissions from all industrial machinery and equipment, including the diesel-powered generators will meet the federal air emission standards. Low sulphur diesel fuel will be used to reduce emissions associated with diesel fuel combustion. In addition, scrubbers will be installed on any mill stacks that emit particulates and contaminants (e.g., acid plant exhaust stack) to remove these items from the air stream before discharge.

Soil admixing has the potential to occur during topsoil stripping and storage of stripped topsoil. Soil admixing will likely occur to varying degrees during topsoil stripping, as topsoil depth varies across the Project development area. To reduce soil admixing, AREVA environmental personnel will be on-site to work with construction crews during the stripping process to help identify areas where the topsoil layer has been adequately stripped to prevent further stripping at these locations. Stripped topsoil will be kept separate from subsoils stored at the overburden pile location to prevent soil admixing, as well as loss of the growth medium layer that will be used for reclamation purposes. Stripped topsoils will also be well-segregated from the ore piles and the Type III mine rock stockpiles to prevent soil contamination. Efforts will be made during the storage process to place frozen or wet soils removed during site preparation within drier soil materials of the same nature (i.e., topsoil, subsoil) to prevent potential migration and

subsequent admixing with other soil or waste rock piles. The stripped topsoil and subsoil materials stored in the overburden pile location will be scanned to ensure no radiation contamination prior to use during site reclamation.

Soils exposed during construction are susceptible to erosion from surface drainage and wind events. Soil erosion from surface drainage can occur as a result of: 1) natural surface drainage from the surrounding area travelling over the Project footprint; and 2) surface drainage from within the Project footprint caused by rain events. Freshwater diversion channels will be constructed to divert surface drainage around the Project footprint, thereby reducing the potential for on-site erosion. Riprap armouring overlying a geotextile will be placed on the channel bottom and side slopes of the diversion channels to mitigate potential erosion of the channel (see Tier 3, Appendix 2E). Other erosion control structures (e.g., sediment breakers, wattles) may also be placed within the diversion channels following initial excavation to reduce the amount of soil erosion by flowing water until vegetation has established or a geotextile liner is placed within the channel. Culverts will be installed where the proposed North All-Season Road crosses natural drainage patterns to facilitate water movement, and in a manner that will prevent scouring of the tundra environment at the culvert outflow location.

Site containment will involve sloping the site pads towards the runoff ponds. However, during construction and prior to site containment, disturbed soils may be susceptible to erosion from surface drainage within the Project footprint caused by precipitation events and snowmelt. If the disturbed areas are deemed to be susceptible to erosion prior to development of site containment, temporary erosion control structures (e.g., silt fences) will be placed on the downslope side of the Project footprint to capture and filter sediment-laden runoff.

Erosion of soils stored in the overburden pile will be monitored throughout the duration of the Project. If climatic events (e.g., precipitation, wind) cause soil erosion from the overburden piles, AREVA will apply mitigation (e.g., the application of a soil tackifier) to the overburden piles to prevent further erosion.

Soil compaction will occur through the duration of the Project due to the movement of vehicles on roads and site pads, as well as placement of infrastructure (e.g., mine plant, accommodations complex). During final closure, areas ready for reclamation will be scarified to loosen compacted soils, allowing for increased success rates of seed germination and sprouting of propagules within the areas being reclaimed. Vehicle travel along the winter roads will likely not cause soil compaction because traffic will be occurring during frozen ground conditions. However, rutting may occur in localized spots where the integrity of the winter road may be compromised. Efforts to identify and avoid vehicle travel on soft spots along the winter road will be employed. Rig matting may also be used to prevent rutting and other disturbances to soils where the winter road's integrity is compromised.

Dust will be created during mining and movement of materials to either the ore piles or waste rock piles. During open pit mining, blasting patterns will be used to control the dispersion of materials as well as dust. Where possible, blasting may also be avoided on days where dust dispersion outside of the Project footprint is anticipated to be excessive due to the prevailing winds speeds. Dust suppression will involve spraying water from a tanker truck affixed with either a spray nozzle or spray bar onto dust-prone areas. If water spraying is not effective in preventing dust occurrence, an adaptive management strategy focusing on additional dust suppression techniques will be investigated, such as using a dust suppressant identified in the GN (2002) guidelines. Speed limits around the mine site and along all roads will be strictly adhered to, to reduce airborne dust from vehicular and other equipment traffic.

Soil Quantity

Best management practices will occur during construction of the Project. Construction activities will likely be postponed during large precipitation events to prevent excessive disturbance to vegetation and soils due to wet working conditions.

During topsoil stripping, efforts will be made to reduce the movement of stripped topsoil when transferring to the overburden pile. For example, topsoil stripped at the far end of the construction area will likely be hauled to the overburden pile using carrying equipment (e.g., buggy scrapers, dump truck) rather than pushing the stripped topsoil to the overburden pile using a bulldozer or grader. This will help prevent soil loss from movement of disturbed soils over the work area.

Preventing soil loss caused by soil movement during the construction phase is important for conserving enough of the growth medium layer for future reclamation purposes. Prior to commencing construction activities, a construction plan for topsoil stripping will be developed based on the topography and terrain features at the proposed mine sites and dock facility. This plan will help determine where stripping will occur, the direction of travel when stripping, taking into consideration terrain features and topography to prevent loss of stripped topsoil as well as where stripped topsoils will be placed. If possible, stripped topsoils will be pushed towards the proposed overburden pile location. Temporary overburden piles may be required in areas where terrain features or topography prevent pushing stripped materials to the overburden pile without causing substantial loss of stripped materials. In these instances, stripped materials will be transported from the temporary overburden piles in either a buggy scraper or dump truck to the final overburden pile location.

Soil burial during development of the roads and airstrip will be confined to the boundaries established from the detailed design for these components. Soil erosion during construction activities has the potential to occur where topsoil stripping or other disturbances to soils have occurred.

8.7 SUMMARY OF COMPLIANCE AND ENVIRONMENTAL MONITORING FOR SOILS

A summary of compliance and environmental monitoring pertaining to soils that will occur during the Project are described below.

Soil Quality

Soil quality will be monitored throughout the duration of the Project. Air emissions and dust deposition monitoring will occur throughout the duration of the Project. Chemical analyses of soil samples from permanent sample plots located within the mine LAA (i.e., exposure plots) and within the RAA (i.e., reference plots) will occur, and comparisons will be made to air emission and dust deposition results, as well as to the baseline values and CCME guidelines. The overburden piles will be routinely checked for erosion, and mitigation measures will be implemented if issues are identified. The winter road will be monitored during use for structural integrity to avoid rutting and/or damage to the underlying soils, and mitigation will be applied to areas of concern. The North All-Season Road will also be monitored for structural integrity and the effectiveness of dust suppression techniques, as well as the effectiveness of culverts for allowing surface drainage while preventing soil scouring.

Soil Quantity

Soil quantity will be monitored primarily during the construction phase of the Project, as well as when any earthwork involving the removal or placement of topsoil is required. An environmental monitor will likely be on-site during the construction phase to assist AREVA personnel and contractors with mitigation strategies to reduce the effects of the Project on soil quantity, such as topsoil stripping, soil storage, and soil erosion on disturbed areas. Dust deposition monitoring will occur throughout the duration of the Project to identify and mitigate potential effects.

9 EFFECTS ASSESSMENT FOR VEGETATION

9.1 SCOPE OF THE ASSESSMENT FOR VEGETATION

9.1.1 Project-Environment Interactions and Effects

Project activities during construction, operation and final closure have the potential to affect vegetation abundance and community diversity, and vegetation quality within the Kiggavik RAA. Key issues related to effects on vegetation include:

- direct loss of vegetation and community diversity due to site clearing and pad construction, as well as construction of freshwater diversions, site drainage containment systems and water/shoreline structures
- deterioration of vegetation quality due to air emissions, including dust deposition, due to Project activities that emit particulates or contaminants, or create dust.

Key Project activities that could affect vegetation abundance and community diversity, and vegetation quality are outlined in Table 9.1-1.

Table 9.1-1 Project-Environment Interactions and Effects on Vegetation

Project Component	Project Activities	Environmental Effect	
		Change in Vegetation Abundance and Community Diversity	Change in Vegetation Quality
Construction			
In-Water Construction	Construct freshwater diversions and site drainage containment systems (dykes, berms, collection ponds)	2	0
	Construct in-water/shoreline structures	2	0
On-Land Construction	Site clearing and pad construction (blasting, earth-moving, loading, hauling, dumping, crushing)	2	2
	Road and airstrip construction	2	2
	Aggregate sourcing	2	2
Supporting Activities	Transport fuel and construction materials	0	2
	Industrial machinery operation	0	2
	Power generation	0	2

Table 9.1-1 Project-Environment Interactions and Effects on Vegetation (cont'd)

Project Component	Project Activities	Environmental Effect	
		Change in Vegetation Abundance and Community Diversity	Change in Vegetation Quality
Operation			
Mining	Mining ore (blasting, loading, hauling)	0	2
	Ore stockpiling	0	2
	Mining special waste (blasting, loading, hauling)	0	2
	Special waste stockpiling	0	2
	Mining clean waste (blasting, loading, hauling)	0	2
	Clean rock stockpiling	0	2
	Underground ventilation	0	2
Milling	Transfer ore to mill	0	2
	Crushing and grinding	0	2
Waste Management	Incineration and handling of burnables	0	2
General Services	Generation of power	0	2
Transportation	Truck transportation	0	2
Final Closure			
General	Industrial machinery operation	0	2
On-land Decommissioning	Remove site pads (blasting, earth-moving, loading, hauling, dumping)	0	2
NOTE: See definitions of rankings in Table 5.6-1			

9.1.2 Measurable Parameters

Table 9.1-2 lists the measurable parameters used to assess Project effects on vegetation abundance, community diversity, and vegetation quality, as well as the rationale for their selection.

Table 9.1-2 Measureable Parameters for Vegetation

VEC	Environmental Effect	Measurable Parameters	Rationale
Vegetation	Change in vegetation abundance	Direct loss of ELC units from Project footprint (km^2)	Direct loss of vegetation may influence biodiversity, which territorial legislation aims to protect
		Direct loss of ELC units that support species of value to Inuit	
	Change in community diversity	Indirect loss from dust deposition and changes in soil chemistry	Dust deposition can influence vegetation abundance and community diversity
	Change in vegetation quality	Change in concentration of COPC in vegetation	Air emissions and dust deposition on vegetation may affect vegetation quality
			Effects on vegetation consumed by animals and people were identified during public engagement sessions

9.1.3 Residual Environmental Effects Criteria for Vegetation

Residual effects on vegetation are characterized quantitatively and qualitatively using the following attributes: direction, magnitude, geographic extent, duration, frequency, and reversibility. Table 9-1-3 provides definitions for these attributes.

Table 9.1-3 Residual Environmental Effects Criteria for Vegetation

Attribute	Rating	Definition
Direction	Positive	Improvement in vegetation abundance and community diversity, or vegetation quality relative to baseline conditions.
	Neutral	No change in vegetation abundance and community diversity, or vegetation quality relative to baseline conditions.
	Adverse	Reduction in vegetation abundance and community diversity, or vegetation quality relative to baseline conditions.
Magnitude	Negligible	No measurable change in vegetation abundance and community diversity, or vegetation quality.
	Low	Effect on one or more of the measurable parameters is detectable, but within the range of natural variation or baseline values; therefore, no change in vegetation abundance and community diversity, or vegetation quality.
	Moderate	Effect on one or more of the measurable parameters is detectable and outside the range of natural variation or baseline values, but is unlikely to change vegetation abundance and community diversity, or vegetation quality.
	High	Effect on one or more of the measurable parameters is detectable and outside the range of natural variation or baseline values; therefore, a change in vegetation abundance and community diversity, or vegetation quality is evident.
Geographic Extent	Site	Effect confined to specific features within Project footprint.
	Local	Effect confined to the LAA.
	Regional	Effect extends beyond the LAA but within the RAA.

Table 9.1-3 Residual Environmental Effects Criteria for Vegetation (cont'd)

Attribute	Rating	Definition
Frequency	Once	Effect occurs once.
	Sporadic	Effect occurs more than once, but at unpredictable intervals.
	Regularly	Effect occurs repeatedly at regular intervals.
	Continuous	Effect occurs continuously throughout the Project.
Duration	Short term	Changes in vegetation abundance and community diversity, or vegetation quality are no longer detectable at the end of construction.
	Medium term	Changes in vegetation abundance and community diversity, or vegetation quality are no longer detectable at the end of final closure.
	Long term	Changes in vegetation abundance and community diversity, or vegetation quality extend beyond the life of the Project.
Reversibility	Reversible	Effect on vegetation is reversible over human scale lifetime.
	Irreversible	Effect is not reversible, or will only reverse on geologic time line (e.g. thousands of years).
Environmental Context	Disturbed	Area has been substantially disturbed previously by human development, or human development is still present.
	Not Disturbed	Area has not been disturbed by human development.

9.1.4 Standards or Thresholds for Determining Significance

9.1.4.1 Vegetation Abundance and Community Diversity

In the absence of threshold values for changes in vegetation abundance and community diversity, the significance of Project effects is based on the number of hectares disturbed of each ELC map unit (i.e., vegetation community) within the respective LAAs. This includes determination of the amount of wetland area disturbed by the Project to comply with the Federal Policy on Wetland Conservation, which has a goal of No Net Loss of wetland function on federal lands and waters.

9.1.4.2 Vegetation Quality

Threshold values for NO_2 and SO_2 concentrations were obtained from the World Health Organization (WHO 2000). The values used in this assessment are:

- annual atmospheric concentrations of SO_2 greater than 10 µg/m^3/year for lichen
- annual atmospheric concentrations of SO_2 greater than 20 µg/m^3/year for all other vegetation
- annual atmospheric concentrations of NO_2 greater than19 µg/m^3/year (assuming NO_2 represents 63% of NO_x, which is greater than 30 µg/m^3/year)

Exceedances of these threshold values have the potential to cause adverse effects in vegetation, with the potential of affecting a plant's growth and yield, as well as potentially changing a plant's sensitivity to other environmental stressors (WHO 2000).

There are no established thresholds for vegetation exposure to dust deposition; however, thresholds for dust pertaining to human health do exist. While the physical and chemical characteristics of dust can vary, the resiliency and tolerance among vegetation species to dust can also vary. For example, Spatt and Miller (1981) noted that sphagnum productivity was affected by dust deposition at a rate of 0.07 g/m^2/day. Auerbach et al. (1997) found that graminoids and deciduous shrubs have an increased biomass in dust-prone areas adjacent to roads in tundra environments; however, the dust deposition rate was not measured. Within Canada, Alberta and Ontario have air quality guidelines that address nuisance dust deposition on human health in residential areas, with threshold values of 5.3 g/m^2/30 days (AENV 2011) and 4.6 g/m^2/30 days (OMOE 2008), respectively.

Threshold values used for this assessment are based on the findings of Spatt and Miller (1981), and the Ontario air quality guidelines for dust deposition on human health. The rates were converted from a daily and monthly rate to a cumulative total annual deposition rate for comparative purposes, as follows.

- Cumulative total of 25 g/m^2/year are predicted to have effects on vegetation quality for some vegetation species (conversion of 0.07 g/m^2/day on sphagnum).
- Cumulative total of 55 g/m^2/year are predicted to cover vegetation with nuisance dust, which may further affect vegetation quality among species (conversion of 4.6 g/m^2/30days for nuisance dust).

Threshold values for PAI on vegetation do not exist. However, the critical load threshold value of 0.25 keq/ha/year for soils was used to identify areas where vegetation may potentially be exposed to high PAI. As stated in CASA (1999), exceedances above the critical load threshold do not mean environmental damage will occur; rather, there is the potential for an effect from PAI on the environment if deposition above the critical load is sustained over many years.

Threshold values for COPC phytotoxicity concentrations do not exist for all types of vegetation, or all COPCs. Where appropriate, phytotoxicity concentrations were obtained from various sources of published literature (see Tier 3, Appendix 8A).

A confidence rating is applied to the significance determination for any residual effects on vegetation. The rating considers the accuracy of the data used for baseline and application of analytical tools, an understanding of the effectiveness of mitigation measures, and an understanding of known responses of the measurable parameters to potential Project effects. The confidence ratings are:

- Low – not confident in prediction, could vary considerably
- Moderate – confident in prediction, moderate variability
- High – confident in prediction, low variability.

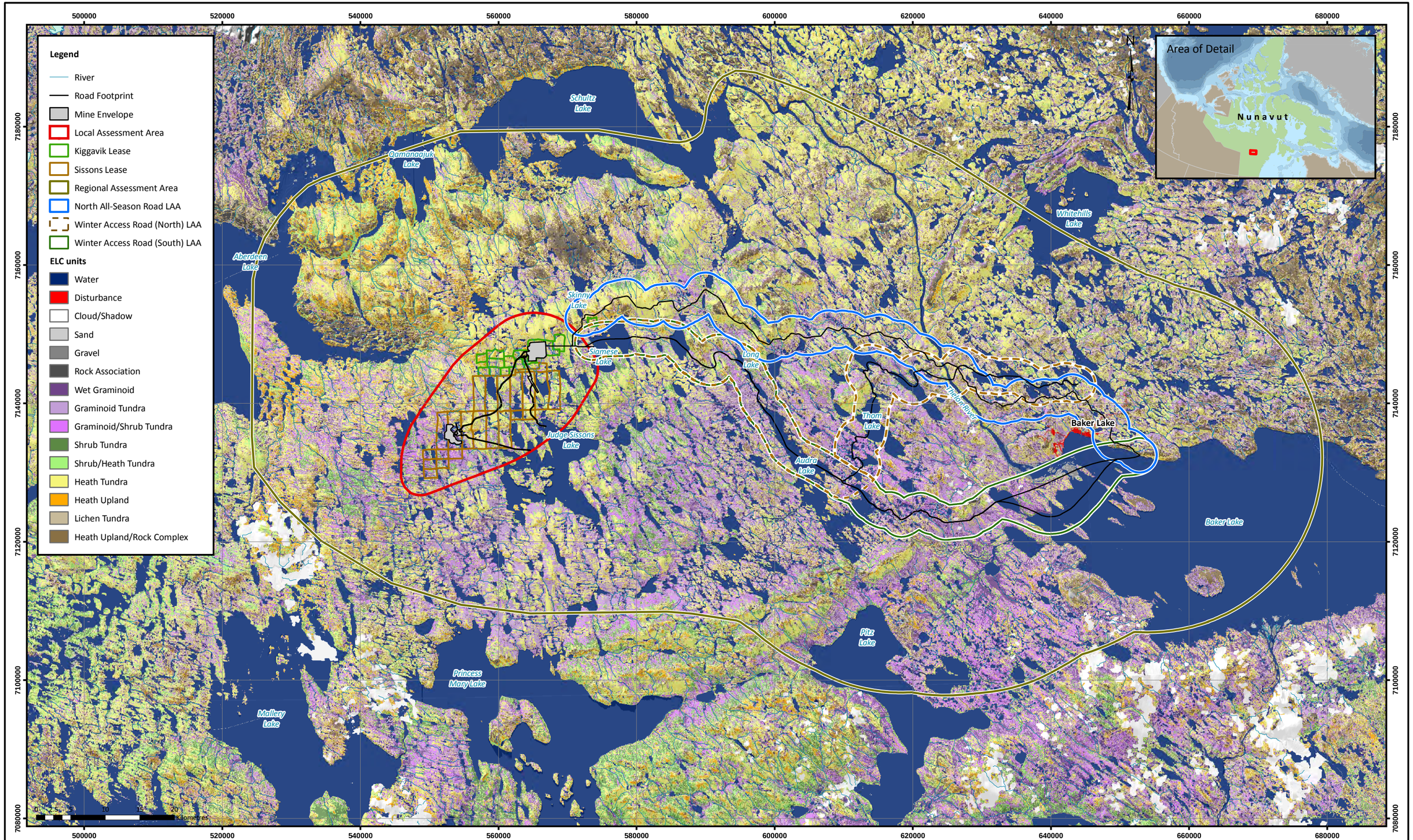
9.2 ASSESSMENT OF CHANGE IN VEGETATION ABUNDANCE AND COMMUNITY DIVERSITY

9.2.1 Analytical Methods for Change in Vegetation Abundance and Community Diversity

Changes to vegetation abundance and community diversity will occur due to the direct effects of vegetation clearing or burying during Project construction. Dust created by Project activities can also be potentially linked to changes in vegetation abundance and community diversity. To assess the potential changes in vegetation abundance and community diversity, vegetation communities within the LAAs and RAA were identified through mapping of ELC units. The Project footprints for the different development options were overlain onto the ELC map to determine those vegetation communities potentially affected by the Project. The ELC map includes map units where vegetation is not the predominant identifier of the map unit (see Section 6.3.2.1 for ELC unit clarification); however, the majority of these ELC units likely have some vegetation occurring within them. As such, all ELC units were included in the analysis.

9.2.2 Baseline Conditions for Change in Vegetation Abundance and Community Diversity

Fifteen ELC units were identified within the LAAs and RAA during baseline surveys (Figure 9.2-1). Nine of these ELC units contain predominately vegetation communities, three ELC units contain predominately granular materials (i.e., sand, gravel, rock association), one ELC unit represents human influence on the landscape (i.e., disturbance), and one ELC unit represents water. One ELC unit represents an unclassifiable area from the satellite imagery (i.e., cloud/shadow). The most abundant ELC units identified in all of the study areas (i.e., mine LAA, road LAAs and RAA) were heath tundra, water and graminoid tundra (Table 9.2-1).



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/09/2011 Scale: 1:500,000
9.2-1_ELC_in_RAA_and_LAAs.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 9.2-1
ECOLOGICAL LAND CLASSIFICATION UNITS IN THE
REGIONAL ASSESSMENT AREA AND LOCAL ASSESSMENT AREAS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

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Table 9.2-1 Distribution of ELC Units

ELC Unit	Mine LAA		Access Road LAAs						Dock LAAs[1]						RAA	
			Winter													
			North		South		North All-Season		Option 1		Option 2		Option 3			
	ha	%	ha	%	ha	%	ha	%	Ha	%	ha	%	ha	%	ha	%
Anthropogenic																
Disturbance	0	0.0%	0	0.0%	0	0.0%	76	0.1%	0.0	0.0%	0.0	0.0%	0.0	0.0%	556	0.1%
Unclassified																
Cloud/Shadow	0	0.0%	51	0.1%	203	0.4%	86	0.2%	0.0	0.0%	0.0	0.0%	0.0	0.0%	2,029	0.2%
Upland																
Sand	6	0.0%	17	0.0%	248	0.4%	32	0.1%	0.0	0.0%	0.2	0.7%	0.1	0.3%	1,852	0.2%
Gravel	83	0.2%	93	0.2%	508	0.9%	146	0.3%	0.1	0.5%	0.2	0.7%	0.6	2.8%	6,979	0.7%
Rock Association*	40	0.1%	236	0.4%	172	0.3%	479	0.9%	0.1	0.2%	0.2	0.8%	0.3	1.5%	10,130	1.0%
Graminoid Tundra*	5,933	13.2%	8,630	16.0%	8,269	14.7%	9,144	17.6%	7.0	26.7%	2.4	7.9%	1.4	6.7%	123,189	12.5%
Graminoid/Shrub Tundra*	4,626	10.3%	4,928	9.1%	5,051	9.0%	3,087	5.9%	0.3	1.0%	0.9	2.8%	0.3	1.2%	79,603	8.1%
Shrub Tundra*	2,698	6.0%	2,142	4.0%	1,776	3.2%	1,694	3.3%	0.2	0.8%	0.3	0.9%	0.0	0.2%	41,639	4.2%
Shrub/Heath Tundra*	3,716	8.3%	3,383	6.3%	2,683	4.8%	3,066	5.9%	0.0	0.1%	1.0	3.3%	0.7	3.3%	59,255	6.0%
Heath Tundra*	16,216	36.0%	11,199	20.8%	8,134	14.5%	18,146	34.9%	11.8	45.0%	15.2	49.6%	11.7	57.6%	241,679	24.6%
Heath Upland*	1,238	2.8%	922	1.7%	952	1.7%	1,287	2.5%	1.4	5.4%	1.5	4.9%	1.4	6.9%	31,304	3.2%
Heath Upland/Rock Complex*	670	1.5%	1,787	3.3%	1,097	2.0%	3,159	6.1%	3.9	14.7%	6.0	19.4%	3.0	14.6%	46,536	4.7%
Lichen Tundra*	578	1.3%	707	1.3%	681	1.2%	857	1.6%	0.3	1.1%	1.5	4.7%	0.6	2.9%	15,820	1.6%
Upland Total	35,804	79.5%	34,043	63.2%	29,570	52.7%	41,097	79.0%	25.1	95.6%	29.4	95.7%	19.9	98.1%	657,986	66.9%
Wetland																
Water	6,079	13.5%	15,852	29.4%	20,827	37.1%	7,655	14.7%	0.2	0.9%	0.3	1.0%	0.1	0.3%	251,161	25.6%
Wet Graminoid*	3,126	6.9%	3,955	7.3%	5,490	9.8%	3,118	6.0%	0.9	3.5%	1.0	3.3%	0.3	1.7%	71,126	7.2%
Wetland Total	9,205	20.5%	19,807	36.7%	26,317	46.9%	10,773	20.7%	1.1	4.4%	1.3	4.3%	0.4	1.9%	322,287	32.8%
Total Area	45,009	100%	53,901	100%	56,090	100%	52,032	100%	26.2	100%	30.7	100%	20.3	100%	982,858	100%

NOTES:

* ELC units containing vegetation species that are harvested by Inuit.

1 All dock options are located within the North All-Season Road LAA, as well as the South Winter Road LAA. Therefore, all calculated areas for each ELC unit within each dock site option are already identified within these LAAs and are not additional areas potentially affected by the Project.

9.2.3 Effect Mechanisms and Linkages for Change in Vegetation Abundance and Community Diversity

A number of different effect mechanisms can contribute to change in vegetation abundance and community diversity during Project development. A summary of the effect mechanisms and how the Project would cause changes in vegetation abundance and community diversity is described below.

9.2.3.1 Site Clearing

Site clearing involves the removal of vegetation from the Project development area, leading to a reduction in vegetation abundance and community diversity. Project components where site clearing will occur include in-water and on-land construction. Site clearing of vegetation will likely occur in conjunction with topsoil stripping. The mixing of vegetation with stripped topsoil will be beneficial to preventing soil erosion from wind events, as well as maintaining the vegetation seedbank within the active growth medium layer.

9.2.3.2 Vegetation Burial

Vegetation burial is the loss of vegetation due to the permanent placement of objects or other materials on top of existing vegetation. The effect of vegetation burial is the direct loss of vegetation from the landscape. Construction of some Project components will not involve clearing of vegetation from the work area; rather, materials will be deposited on top of the existing vegetation in an effort to avoid disturbing the thermal barrier that prevents thawing of the permafrost layer. As such, the vegetation (and underlying soils) will be buried. Specifically, the components where vegetation burial will occur include the Kiggavik-Sissons access road, the proposed North All-Season Road, the airstrip, and maintenance roads within the Kiggavik and Sissons footprints.

Vegetation burial will likely also occur during development of the winter ice road. Portions of the winter ice road travelling over-land will likely require placement of a granular surface pad on top of the existing terrain to provide a level travel surface in areas of rugged microtopography.

9.2.3.3 Invasive Species

There is the potential for invasive species to be introduced to the area from seeds attached to equipment and supplies brought in from outside the region. Kubanis (1980) found 13 introduced plant species along the Dalton Highway, of which nine species were determined to be reproducing in the area. However, none of the introduced species were deemed to be invading native plant communities (NRC 2003). A combination of variables such as the harsh climatic conditions, short growing season, and nutrient-deficient soils found in a tundra environment reduce the potential for invasive plant species to establish and proliferate. Vegetation species that do invade the area may not be native to that particular type of vegetation community;

however, the species may occur in other vegetation communities that are adaptive to disturbance within the tundra environment (e.g., coastal or dune environments). NRC (2003) noted that invasion by non-native plant species to the tundra environment located adjacent to the Dalton Highway in Alaska has not been a major issue.

9.2.4 Mitigation Measures and Project Design for Change in Vegetation Abundance and Community Diversity

The following mitigation measures will be implemented to reduce Project effects on vegetation abundance and community diversity.

- Pre-construction surveys will be completed of the surveyed Project footprint boundaries for listed species to confirm their absence from the area to be disturbed.
- Where possible, access routes will be deflected to avoid any sensitive species identified during the pre-construction surveys.
- If sensitive species are located within the Project footprint, transplanting of species will occur at a suitable location. AREVA will consult with the GN regarding acceptable transplanting locations.
- Construction activities will likely be postponed during large precipitation events to prevent excessive disturbance to vegetation due to wet working conditions.
- Site clearing and vegetation burial will occur within the confines of the Project footprint to reduce the potential for additional vegetation loss and prevent unnecessary disturbance to vegetation adjacent to the Project development area.
- The vegetation seedbank will be preserved during topsoil stripping and stockpiling that will be used to facilitate natural regeneration of native vegetation in reclaimed areas.
- Waterbodies and watercourses were selected as much as possible during routing of the proposed winter roads to avoid disturbing vegetation communities.
- Rig matting may be used along the winter road in areas where granular material is not practical to prevent damaging the underlying vegetation.
- All equipment and machinery will be cleaned of foreign particles (e.g., soil, thatch) prior to initial transport to the Project to prevent the introduction of invasive and/or non-native vegetation.
- Progressive reclamation will occur throughout the Project on decommissioned areas to return disturbed areas to a natural state.

9.2.5 Residual Effects for Change in Vegetation Abundance and Community Diversity

No residual effects on vegetation abundance and community diversity are predicted to occur outside of the LAAs. A description of the predicted residual effects within each LAA is provided below.

Residual effects of site clearing and vegetation burial on the ELC units are discussed below for each LAA and the RAA, and are summarized in Table 9.2-2.

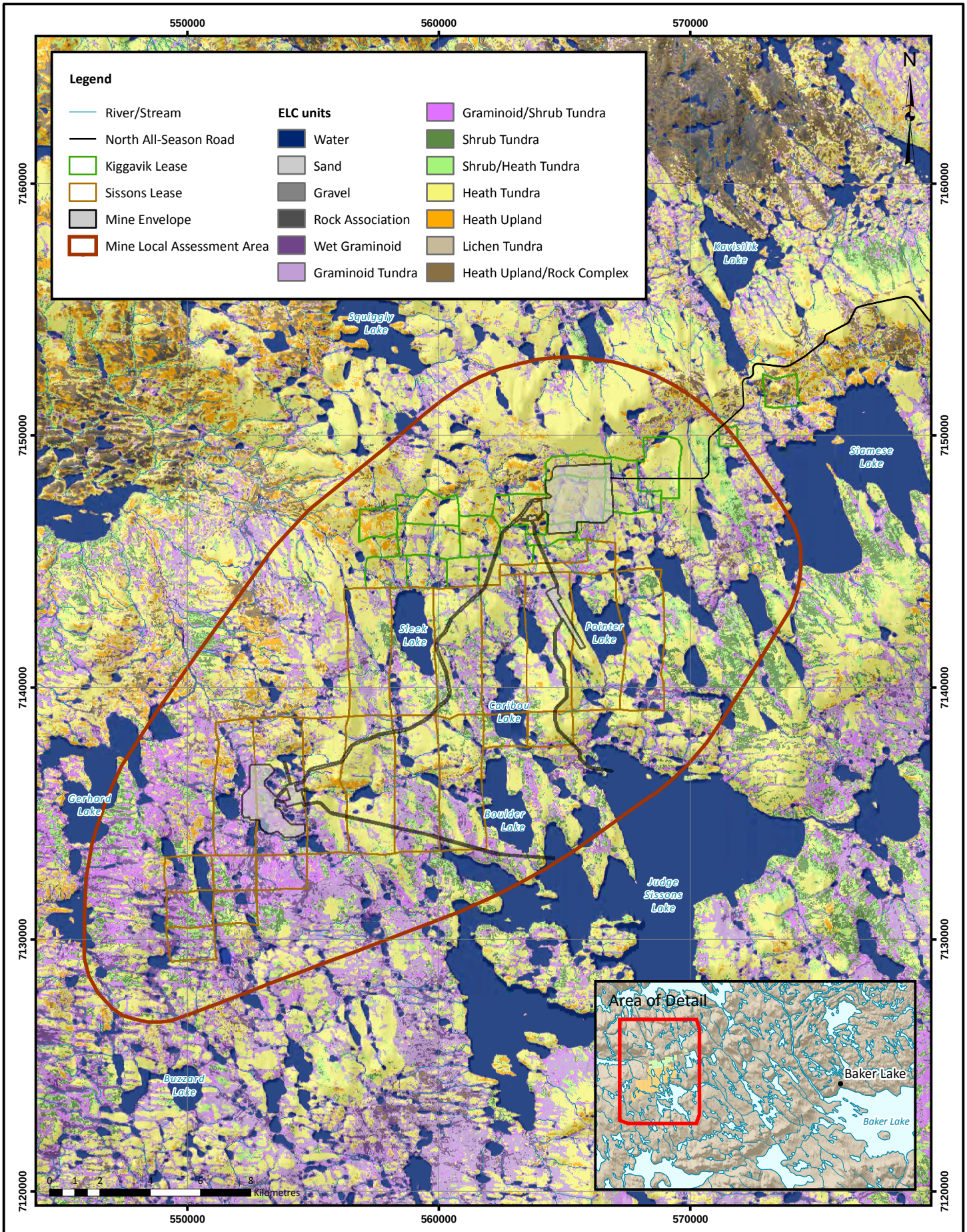
9.2.5.1 Mine LAA

The Kiggavik and Sissons mine footprints are predicted to disturb a total area of 1,378 ha, which represents 3.1% of the mine LAA and 0.14% of the RAA (Figure 9.2-2). The ELC map units with the greatest decrease in area within the mine LAA are heath tundra (660.1 ha), graminoid/shrub tundra (198.7 ha) and graminoid tundra (182.6 ha). This represents relative losses to these vegetation communities of 4.1%, 4.3%, and 3.1%, respectively. Disturbance to wetland ELC units (water and wet graminoid) within the mine LAA constitutes 22.1 ha and 49.8 ha, respectively. This represents relative losses of 0.4% and 1.6% to these map units, respectively. The total relative loss of ELC map units that contain vegetation of cultural importance to Inuit represents about 3% of the mine LAA.

Changes in vegetation abundance and community diversity within the mine LAA are anticipated to be low in magnitude with an approximate loss of 3.1% of the mine LAA, residual effects will be site specific in geographic extent, likely to occur only during the construction phase of the Project, and be long term but reversible through reclamation.

9.2.5.2 North Winter Road LAA

Approximately 139.3 ha are expected to be disturbed as a result of clearing and vegetation burial during construction of the proposed North Winter Road, which represents approximately 0.3% of the North Winter Road LAA (Figure 9.2-2). It is estimated that the North Winter Road will traverse about 97.2 ha of the water ELC map unit, which represents 69.8% of the area affected by the North Winter Road. The ELC map units with the greatest decrease in area within the North Winter Road LAA are heath tundra (10.5 ha), graminoid tundra (9.5 ha) and wet graminoid (6.7 ha). The relative losses of each of the ELC map units within the North Winter Road LAA are less than 1%. The total relative loss of ELC map units that contain vegetation of cultural importance to Inuit represents less than 1% of the North Winter Road LAA.



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/09/2011 Scale: 1:200,000
File: 9.2-2_ELC_in_Mine_LAA.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 9.2-2
ECOLOGICAL LAND CLASSIFICATION UNITS
WITHIN THE MINE LOCAL ASSESSMENT AREA

ENVIRONMENTAL IMPACT STATEMENT
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Table 9.2-2 Surface Disturbance to the Ecological Landscape Classification Map Units

ELC Unit	Mine LAA			Access Road LAAs									RAA		
				Winter											
				North			South			North All-Season Road					
	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed[2]	Change	Existing	Disturbed[3]	Change
	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss	ha	ha	%Loss	ha	ha	% Loss
Anthropogenic															
Disturbance	0	0	0%	0	0	0%	0	0	0%	76	0.0	0%	556	0.0	0.0%
Unclassified															
Cloud/Shadow	0	0	0%	51	0	0%	203	0	0%	86	0.0	0%	2,029	0.0	0.0%
Upland															
Sand	6	0.0	0.0%	17	0.0	0.0%	248	0.4	0.1%	32	0.0	0.1%	1,852	0.7	0.0%
Gravel	83	2.3	2.8%	93	0.0	0.0%	508	1.7	0.3%	146	0.2	0.1%	6,979	5.0	0.1%
Rock Association*	40	1.5	3.8%	236	0.2	0.1%	172	0.0	0.0%	479	1.6	0.3%	10,130	3.7	0.0%
Graminoid Tundra*	5,933	182.6	3.1%	8,630	9.5	0.1%	8,269	18.7	0.2%	9,144	46.0	0.5%	123,189	259.7	0.2%
Graminoid/Shrub Tundra*	4,626	198.7	4.3%	4,928	4.7	0.1%	5,051	9.3	0.2%	3,087	11.4	0.4%	79,603	221.9	0.3%
Shrub Tundra*	2,698	62.8	2.3%	2,142	2.5	0.1%	1,776	2.9	0.2%	1,694	7.8	0.5%	41,639	74.4	0.2%
Shrub/Heath Tundra*	3,716	117.2	3.2%	3,383	6.1	0.2%	2,683	7.3	0.3%	3,066	16.6	0.5%	59,255	142.8	0.2%
Heath Tundra*	16,216	660.1	4.1%	11,199	10.5	0.1%	8,134	12.9	0.2%	18,146	128.5	0.7%	241,679	836.8	0.3%
Heath Upland*	1,238	44.7	3.6%	922	0.5	0.1%	952	0.6	0.1%	1,287	11.1	0.9%	31,304	60.5	0.2%
Heath Upland/Rock Complex*	670	14.2	2.1%	1,787	0.7	0.0%	1,097	0.7	0.1%	3,159	21.6	0.7%	46,536	47.5	0.1%
Lichen Tundra*	578	21.9	3.8%	707	0.6	0.1%	681	1.1	0.2%	857	6.8	0.8%	15,820	32.3	0.2%
Upland Total	35,804	1,305.9	3.6%	34,043	35.4	0.1%	29,570	55.6	0.2%	41,097	251.6	0.6%	657,986	1,685.3	0.3%
Wetland															
Water	6,079	22.1	0.4%	15,852	97.2	0.6%	20,827	82.8	0.4%	7,655	0.7	0.0%	251,161	165.5	0.1%
Wet Graminoid*	3,126	49.8	1.6%	3,955	6.7	0.2%	5,490	11.6	0.2%	3,118	7.1	0.2%	71,126	75.5	0.1%
Wetland Total	9,205	72.0	0.8%	19,807	103.9	0.5%	26,317	94.4	0.4%	10,773	7.8	0.1%	322,287	241.1	0.1%
Total Area	45,009	1,378	3.1%	53,901	139.3	0.3%	56,090	150.0	0.3%	52,032	259.4	0.5%	982,858	1,926.4	0.2%

NOTES:
* - ELC units containing vegetation species that are harvested by Inuit
1 - All dock options are located within the North All-Season Road LAA, as well as the South Winter Road LAA. Therefore, all calculated disturbed areas for each ELC unit within each dock site option are included within these
2 - The portion of the North All-Season Road that extends from Dock Option 1 to Dock Options 2 and 3 is not included in the calculated area, as it has been included in the estimate for both Dock Options 2 and 3
3 - The calculated area of disturbance within the RAA includes the Mine footprint, footprints for all road options (North Winter Road, South Winter Road and North All-Season Road, and Dock Options 1, 2 & 3

Changes in vegetation abundance and community diversity as a result of construction of the North Winter Road are anticipated to be low in magnitude, with relative losses to the ELC map units amounting to less than 1% of the LAA. The residual effect will be site-specific, likely to occur only during the construction phase of the Project and be long term but reversible through reclamation.

9.2.5.3 South Winter Road LAA

Approximately 150 ha will be disturbed as a result of clearing and vegetation burial during construction of the proposed South Winter Road, which represents approximately 0.3% of the South Winter Road LAA (Figure 9.2-2). It is estimated that the South Winter Road will traverse about 82.8 ha of the water ELC map unit, which represents 55.2% of the area affected by the South Winter Road. The ELC map units with the greatest decrease in area (other than water) within the South Winter Road LAA are graminoid tundra (18.7 ha), heath tundra (12.9 ha), and wet graminoid (11.6 ha). The relative losses of each of the ELC map units within the South Winter Road LAA are less than 1%. The total relative loss of ELC map units that contain vegetation of cultural importance to Inuit represents less than 1% of the South Winter Road LAA.

Changes in vegetation abundance and community diversity as a result of the South Winter Road are anticipated to be low in magnitude, with relative losses to the ELC map units amounting to less than 1% of the LAA. The residual effects will be site-specific in geographic extent, likely to occur only during the construction phase of the Project, and will be long term but reversible through reclamation.

9.2.5.4 North All-Season Road LAA

The North All-Season Road is estimated to disturb approximately 259.4 ha, which represents approximately 0.5% of the North All-Season Road LAA (Figure 9.2-2). Heath tundra will be most affected by construction of the North All-Season Road, with a decrease in area of about 128.5 ha, which represents 49.5% of the total area affected by the North All-Season Road. Other ELC map units with substantial decreases in area include graminoid tundra (46 ha), heath upland/rock complex (21.6 ha) and shrub/heath tundra (16.6 ha). The relative losses of each of the ELC map units within the North All-Season Road LAA are less than 1%. The total relative loss of ELC map units that contain vegetation of cultural importance to Inuit represents less than 1% of the North All-Season Road LAA.

While the -North All-Season Road option will affect a larger area than the winter road options (i.e., 0.5% of the North All-Season Road LAA compared to 0.3% of both the North Winter Road and South Winter Road LAAs), the relative loss of each of the ELC map units within the LAA will still be less than 1%. Therefore, the residual effect of the North All-Season Road option is expected to be similar to the winter road options (i.e., low in magnitude, site-specific in geographic extent). As with the winter road options, the residual effect will likely only occur

during the construction phase of the Project, and will be long term but reversible through reclamation.

9.2.5.5 Dock Site Options

The dock facility is encompassed within the North All-Season Road LAA and the South Winter Road LAA. As such, the estimated areas of each ELC unit affected by the site options are included within these LAAs. The segment of the North All-Season Road that commences at the junction of the road segment to dock site option #1 (preferred) and travels towards dock site options #2 and #3 has been included in the calculations for dock site options #2 and #3 (Figure 9.2-3). The total area disturbed by each of the proposed dock site options is summarized in Table 9.2-2.

The residual effect from invasive species on the existing vegetation community within all of the LAAs is anticipated to be negligible, as described in Section 9.2.3.3.

9.2.5.6 Project Development Option Combinations

As discussed in the Project Description (Tier 2, Volume 2), a winter road will be constructed to support both the construction and operation phases of the Project. An all-season road with a cable-ferry crossing the Thelon River has also been included as a viable option. A comparison of the changes in vegetation abundance and community diversity under the different Project development options is summarized in Tables 9.2-3 and 9.2-4.

South Winter Road and Dock Site Option #1 with the Mine Sites

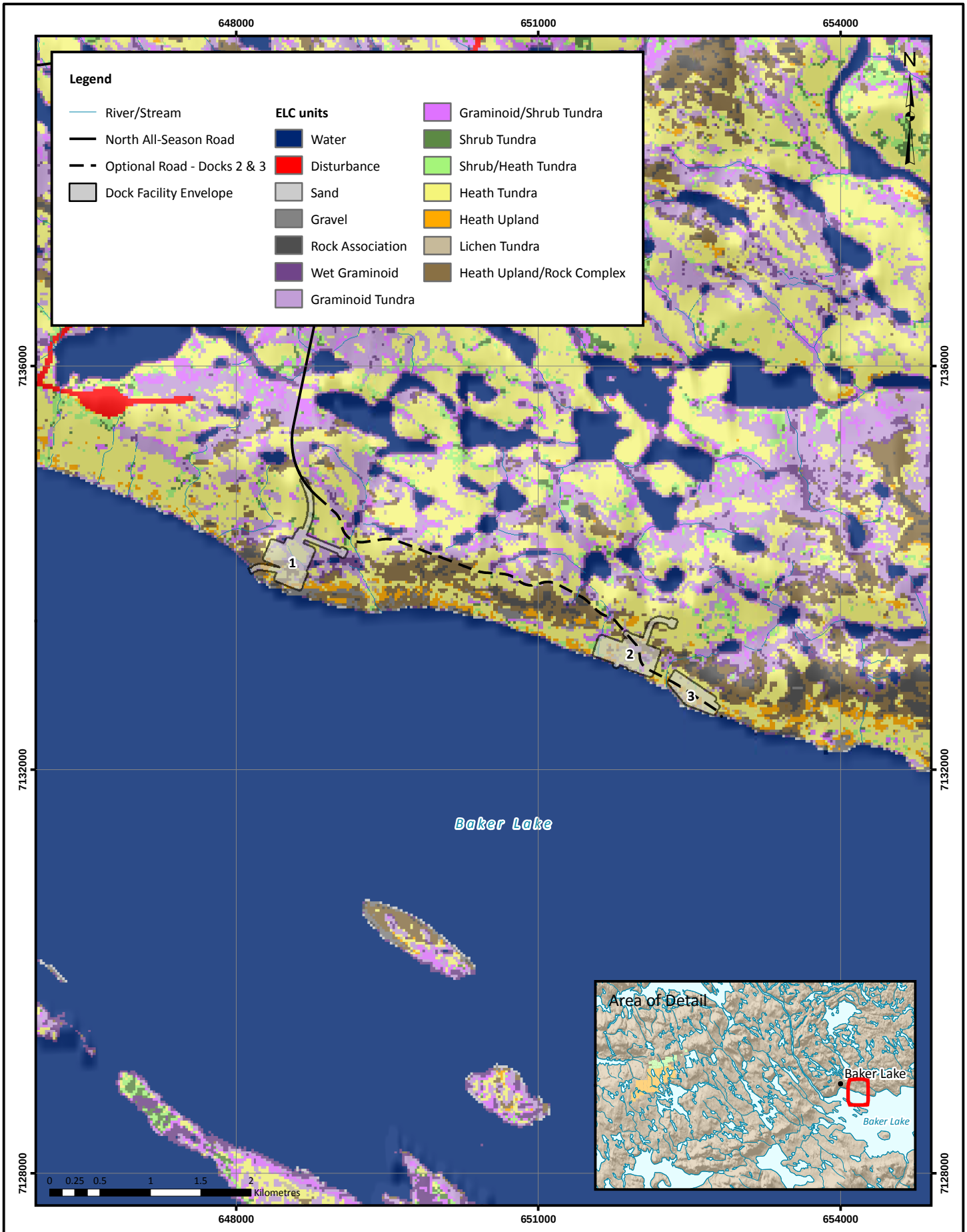
A total of 1,554 ha is predicted to be affected by construction of the South Winter Road, mine sites and dock facility at the preferred (option #1) site location (Table 9.2-3). Of this, 1,449 ha have the potential to support vegetation, as about 105 ha covers frozen waterbodies and watercourses (not including the wet graminoid ELC unit). The 1,449 ha to be affected represents approximately 1.4% of the combined LAAs.

Wetlands make up about 35,523 ha, or 35% of the LAAs (Table 9.2-3). Of this, about 37% supports vegetation (i.e., wetland graminoid ELC map unit). Approximately 168 ha (or 0.5% of the wetland area) is expected to be lost. The highest percent loss for any of the ELC map units is 2.8%, represented by the heath tundra vegetation community. The total relative loss of ELC map units that contain vegetation of cultural importance to Inuit represents 2% of this development option combination. Therefore, the residual effect from this development option combination on vegetation abundance and community diversity is anticipated to be low in magnitude and site specific in geographic extent. The effect will occur during the construction phase and will be long term in duration but reversible with reclamation.

Table 9.2-3 Changes to the ELC Map Units Based on Project Development Options

ELC Unit	Local Assessment Area Scenarios																	
	Mine LAA, North Winter Road LAA, and Dock Site Option #1			Mine LAA, North Winter Road LAA, and Dock Site Option #2			Mine LAA, North Winter Road LAA, and Dock Site Option #3			Mine LAA, South Winter Road LAA, and Dock Site Option #1			Mine LAA, South Winter Road LAA, and Dock Site Option #2			Mine LAA, South Winter Road LAA, and Dock Site Option #3		
	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change
	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss
Anthropogenic																		
Disturbance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified																		
Cloud/Shadow	51.1	0.0	0.0	51.1	0.0	0.0	51.1	0.0	0.0	203.3	0.0	0.0	203.3	0.0	0.0	203.3	0.0	0.0
Upland																		
Sand	23.3	0.0	0.0	23.5	0.2	0.9	23.3	0.1	0.3	253.5	0.4	0.1	253.7	0.6	0.2	253.6	0.4	0.2
Gravel	175.9	2.4	1.4	176.0	2.5	1.4	176.4	2.9	1.6	591.2	4.1	0.7	591.3	4.2	0.7	591.6	4.6	0.8
Rock Association*	275.6	1.8	0.6	275.8	2.0	0.7	275.9	2.0	0.7	211.6	1.6	0.7	211.7	1.7	0.8	211.8	1.8	0.8
Graminoid Tundra*	14,569.7	199.1	1.4	14,565.1	194.5	1.3	14,564.1	193.4	1.3	14,208.5	208.3	1.5	14,203.9	203.7	1.4	14,202.9	202.6	1.4
Graminoid/Shrub Tundra*	9,554.1	203.7	2.1	9,554.7	204.3	2.1	9,554.0	203.7	2.1	9,677.1	208.3	2.2	9,677.7	208.9	2.2	9,677.1	208.2	2.2
Shrub Tundra*	4,840.2	65.5	1.4	4,840.3	65.5	1.4	4,840.0	65.3	1.3	4,474.7	65.9	1.5	4,474.7	65.9	1.5	4,474.5	65.7	1.5
Shrub/Heath Tundra*	7,099.3	123.3	1.7	7,100.3	124.2	1.7	7,100.0	123.9	1.7	6,399.1	124.5	1.9	6,400.1	125.5	2.0	6,399.7	125.1	2.0
Heath Tundra*	27,426.4	682.4	2.5	27,429.8	685.8	2.5	27,426.3	682.3	2.5	24,361.9	684.8	2.8	24,365.3	688.2	2.8	24,361.8	684.7	2.8
Heath Upland*	2,161.9	46.6	2.2	2,162.0	46.7	2.2	2,161.9	46.6	2.2	2,191.2	46.7	2.1	2,191.3	46.8	2.1	2,191.2	46.7	2.1
Heath Upland/Rock Complex*	2,460.4	18.8	0.8	2,462.5	20.9	0.8	2,459.5	17.9	0.7	1,771.0	18.8	1.1	1,773.2	20.9	1.2	1,770.1	17.9	1.0
Lichen Tundra*	1,285.0	22.8	1.8	1,286.2	24.0	1.9	1,285.3	23.1	1.8	1,259.4	23.3	1.8	1,260.6	24.4	1.9	1,259.7	23.5	1.9
Upland Total	69,871.8	1,366.3	2.0	69,876.1	1,370.6	2.0	69,866.6	1,361.1	1.9	65,399.1	1,386.5	2.1	65,403.4	1,390.9	2.1	65,393.9	1,381.4	2.1
Wetland																		
Water	21,930.8	119.6	0.5	21,930.9	119.7	0.5	21,930.6	119.4	0.5	26,906.4	105.2	0.4	26,906.4	105.3	0.4	26,906.2	105.0	0.4
Wet Graminoid*	7,082.1	57.4	0.8	7,082.2	57.5	0.8	7,081.6	56.8	0.8	8,617.0	62.3	0.7	8,617.1	62.4	0.7	8,616.4	61.7	0.7
Wetland Total	29,012.9	177.0	0.6	29,013.1	177.2	0.6	29,012.2	176.3	0.6	35,523.3	167.5	0.5	35,523.5	167.7	0.5	35,522.6	166.7	0.5
Total Area	98,884.7	1,543.3	1.6	98,889.2	1,547.8	1.6	98,878.8	1,537.4	1.6	101,125.6	1,554.0	1.5	101,130.1	1,558.5	1.5	101,119.7	1,548.1	1.5

NOTES:
* - ELC units containing vegetation species that are harvested by Inuit
Highlighted area represents the preferred development option combination



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/09/2011 Scale: 1:50,000
File: 9.2-3_ELC_in_Dock_Vicinity.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 9.2-3
ECOLOGICAL LAND CLASSIFICATION UNITS
LOCATED AT THE PROPOSED DOCK SITE OPTIONS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project

AREVA

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North All-Season Road combined with the South Winter Road, Dock Site Option #1 and the Mine Sites

The total area disturbed by this development option is estimated to be about 1,814 ha (Table 9.2-4). Of this, approximately 1,708 ha of upland area that likely supports vegetation will likely be lost, which represents approximately 1.5% of the combined LAAs.

The LAAs for this development option contain about 46,296 ha of wetlands; however, only about 175 ha, or 0.4% of the wetlands located within the LAAs will be affected by construction of the Project components (Table 9.2-4).

Heath tundra, graminoid tundra and graminoid/shrub tundra will be most affected by this development option, with losses of about 813 ha, 254 ha and 220 ha, respectively. These vegetation communities comprise approximately 35.8%, 19.7%, and 10.8% of the ELC map units located within the LAAs that can support vegetation, respectively. The greatest decrease in area in relation to the ELC map units will be heath tundra (1.9%), graminoid/shrub tundra (1.7%), and heath upland (1.7%). Approximately 1.5% of the ELC map units that contain vegetation of cultural importance to Inuit will be disturbed by this development option combination.

The predicted residual effects from this development option are anticipated to be low in magnitude and will be site specific in geographic extent. Disturbance to vegetation abundance and community diversity will occur during the construction phase and the residual effects will be long term in duration; however, the residual effects will be reversible with reclamation.

Alternate Development Options

The vegetation losses under the alternate development options and their potential combinations are similar to the preferred options in relation to vegetation abundance and community diversity, as shown in Tables 9.2-3 and 9.2-4. As such, the difference between the preferred development options and the alternate development options in relation to the residual effects are anticipated to be negligible.

9.2.6 Determination of Significance for Change in Vegetation Abundance and Community Diversity

The greatest predicted decrease among all ELC map units within the LAAs is less than 3% (with loss of wetland area representing only 0.5%). Further, the greatest total relative loss of ELC map units containing vegetation that are of cultural importance to Inuit was 3% within the mine LAA, and no more than 2% within the combined LAAs for the development option combinations. Consequently, changes in vegetation abundance and community diversity are predicted to be not significant.

Table 9.2-4 Changes to the ELC Map Units Based on the Different Development Options that Include the North All-Season Road

ELC Unit	Local Assessment Area Scenarios																	
	Mine LAA, North All-Season Road LAA, North Winter Road LAA, and Dock Site Option #1			Mine LAA, North All-Season Road LAA, North Winter Road LAA, and Dock Site Option #2			Mine LAA, North All-Season Road LAA, North Winter Road LAA, and Dock Site Option #3			Mine LAA, North All-Season Road LAA, South Winter Road LAA, and Dock Site Option #1			Mine LAA, North All-Season Road LAA, South Winter Road LAA, and Dock Site Option #2			Mine LAA, North All-Season Road LAA, South Winter Road LAA, and Dock Site Option #3		
	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change	Existing	Disturbed	Change
	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss	ha	ha	% Loss
Anthropogenic																		
Disturbance	76	0.0	0.0	76	0.0	0.0	76	0.0	0.0	76	0.0	0.0	76	0.0	0	76	0.0	0.0
Unclassified																		
Cloud/Shadow	137	0.0	0.0	137	0.0	0.0	137	0.0	0.0	289	0.0	0.0	289	0.0	0	289	0.0	0.0
Upland																		
Sand	55	0.0	0.1	55	0.2	0.4	55	0.1	0.2	286	0.4	0.1	286	0.6	0.2	286	0.5	0.2
Gravel	322	2.6	0.8	322	2.7	0.8	322	3.1	0.9	737	4.3	0.6	737	4.4	0.6	738	4.8	0.6
Rock Association*	755	3.4	0.4	755	3.6	0.5	755	3.6	0.5	691	3.1	0.5	691	3.3	0.5	691	3.4	0.5
Graminoid Tundra*	23,714	245.0	1.0	23,709	240.4	1.0	23,708	239.4	1.0	23,353	254.2	1.1	23,348	249.6	1.1	23,347	248.6	1.1
Graminoid/Shrub Tundra*	12,641	215.0	1.7	12,642	215.7	1.7	12,641	215.0	1.7	12,764	219.6	1.7	12,765	220.2	1.7	12,764	219.6	1.7
Shrub Tundra*	6,534	73.3	1.1	6,534	73.3	1.1	6,534	73.1	1.1	6,169	73.7	1.2	6,169	73.7	1.2	6,168	73.5	1.2
Shrub/Heath Tundra*	10,165	139.9	1.4	10,166	140.9	1.4	10,166	140.5	1.4	9,465	141.1	1.5	9,466	142.1	1.5	9,466	141.8	1.5
Heath Tundra*	45,572	810.9	1.8	45,576	814.3	1.8	45,572	810.8	1.8	42,508	813.2	1.9	42,511	816.7	1.9	42,508	813.1	1.9
Heath Upland*	3,449	57.7	1.7	3,449	57.9	1.7	3,449	57.7	1.7	3,478	57.8	1.7	3,478	58.0	1.7	3,478	57.8	1.7
Heath Upland/Rock Complex*	5,619	40.4	0.7	5,621	42.5	0.8	5,618	39.5	0.7	4,930	40.5	0.8	4,932	42.6	0.9	4,929	39.6	0.8
Lichen Tundra*	2,142	29.6	1.4	2,143	30.8	1.4	2,142	29.9	1.4	2,116	30.1	1.4	2,118	31.2	1.5	2,117	30.4	1.4
Upland Total	110,969	1,617.9	1.5	110,973	1,622.2	1.5	110,964	1,612.7	1.5	106,496	1,638.1	1.5	106,500	1,642.5	1.5	106,491	1,633.0	1.5
Wetland																		
Water	29,586	120.3	0.4	29,586	120.4	0.4	29,586	120.1	0.4	34,561	105.9	0.3	34,561	106.0	0.3	34,561	105.7	0.3
Wet Graminoid*	10,200	64.5	0.6	10,200	64.6	0.6	10,200	63.9	0.6	11,735	69.4	0.6	11,735	69.5	0.6	11,734	68.8	0.6
Wetland Total	39,786	184.8	0.5	39,786	185.0	0.5	39,785	184.1	0.5	46,296	175.3	0.4	46,297	175.5	0.4	46,296	174.6	0.4
Total Area	150,968	1,802.7	1.2	150,972	1,807.3	1.2	150,962	1,796.8	1.2	153,158	1,813.5	1.2	153,162	1,818.0	1.2	153,152	1,807.6	1.2

NOTES:
* - ELC units containing vegetation species that are harvested by Inuit.
Highlighted area represents the preferred development option combination.

Overall, confidence in this prediction is considered high for the following reasons.

- Confidence is high with respect to the determination of the area affected by the Project, and the residual effects associated with the different Project development combinations.
- The effectiveness of mitigation measures to reduce the effects of Project activities on vegetation is well understood.

9.2.7 Compliance and Environmental Monitoring for Change in Vegetation Abundance and Community Diversity

Compliance and environmental monitoring for changes in vegetation abundance and community diversity will include the following:

- An environmental monitor will be onsite during all phases of the Project to work with AREVA personnel and contractors to meet and comply with environmental regulations associated with vegetation.
- Permanent sampling plots will be established around the Project Footprint and adjacent to the proposed access roads. These sampling plots will be routinely surveyed and assessed to measure potential changes in vegetation abundance and community diversity.
- Monitoring for invasive species will be completed throughout the duration of the Project. Attempts will be made to remove any invasive species identified adjacent to the Project footprint.

9.3 ASSESSMENT OF CHANGE IN VEGETATION QUALITY

9.3.1 Analytical Methods for Change in Vegetation Quality

Project construction and operation activities will generate dust that contains metals and radionuclides. The COPC included in this assessment include uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, and zinc. Detailed modelling of concentrations of these COPC in dust was completed as part of the Atmospheric Assessment (Tier 2, Volume 4), and formed the basis for estimating changes in vegetation concentrations. The SENES INTAKE model was used to estimate COPC concentrations in soil and vegetation. This model was selected to allow an integrated approach for estimating environmental quality, ecological risk assessment and human health (see Tier 3, Appendix 8A). The model has been used extensively on other uranium mining projects.

The vegetation assessment considers the effects of dust deposition on different classes of vegetation including berries, browse (e.g. willow, birch), forage (e.g. sedges, grass) and lichen. These vegetation classes were selected based on the characteristics of the area and utilization of vegetation by ecological receptors and people. Changes to vegetation COPC concentrations were estimated by applying values for uptake rates derived from site-specific information and expected deposition behaviour. The lichen model was updated to provide a more accurate representation of the expected response to deposition of airborne radionuclides and metals.

The Project will also generate air emissions from fossil fuel combustion that could affect vegetation quality. Effects from air emissions on vegetation quality can occur directly through fumigation of nitrogen oxides and sulphur dioxides, or indirectly as a result of changes in soil chemistry from PAI. Adverse effects on vegetation health due to exposure to NO_x and SO_2, as well as changes in COPC concentration within the vegetation, are evaluated, based on comparisons to phytotoxicity limits. The amount of area where PAI deposition occurs on the ELC map units is estimated, based on the defined critical levels.

The effects of air emission varies among vegetation species due to many variables (e.g., vascular vs. non-vascular plants, resiliency to changes in air quality). Although some species might be affected by air emissions, the response of individual species will be highly variable and relate to factors such as competition in addition to individual species sensitivity. As individual species responses are not well defined, effects of air emissions are assessed in terms of the vegetation communities (i.e., ELC map units).

9.3.2 Baseline Conditions for Change in Vegetation Quality

During baseline surveys, vegetation samples were collected to determine existing analyte concentrations. Plant tissue chemistry results for metals and radionuclide concentrations are presented in Tier 3, Appendix 6B, Section 4. Guidelines pertaining to analyte concentrations within vegetation do not exist.

Air quality sampling was also completed during the baseline surveys. A summary of the baseline air quality measurements for metals and radionuclides at the Kiggavik mine site are presented in the Air Dispersion Assessment report (i.e., Tier 3, Appendix 4B). Background PAI levels were calculated based on data from the National Atmospheric Chemistry Precipitation Database (NAtChem) (NAtChem 2008). The annual average background PAI was calculated to be 0.093 keq/ha/yr.

Collection of baseline data on TSP was attempted in 2010; however, unforeseen challenges with equipment may have affected the reliability of these data (i.e., measured particulate concentration). Consequently, no useable particulate data currently exists for the Kiggavik mine site. Monitoring is currently underway.

9.3.3 Effect Mechanism and Linkages for Change in Vegetation Quality

Air emissions and dust deposition from construction and operation activities of the Project have the potential to affect the quality of vegetation within the LAA.

9.3.3.1 Air Emissions

Air emissions from Project activities that are anticipated to operate continuously (e.g., diesel generators for power production) or produce large quantities of emissions (e.g., industrial machinery or heavy equipment, acid plant) have the potential to affect vegetation quality. During operation, dust from the mine, airstrip and roads may also contribute to acidification of soils, which can affect vegetation quality and community structure (Myers-Smith et al. 2006). PAI can also affect vegetation indirectly through acidification of soils, which can lead to defoliation, discoloration and reduced growth of vegetation (WHO 2000). Sections 8.2.3 through 8.2.5 provide an assessment of the effects of PAI on soil quality. A description of other types of air emissions produced and how they may affect vegetation quality is provided below.

Sulphur Dioxide (SO_2)

Effects from SO_2 fumigation include changes to plant physiology and fitness. Sulphur is a micronutrient required by plants in trace amounts. When supplied amounts of sulphur exceed a plant's needs, changes to growth and reproduction can occur. Effects that alter vegetation quality can also affect diversity through changes in community composition. Lichens are the most sensitive species to SO_2 fumigation because they get most of their nutrients from the atmosphere and lack protective structures such as thick cuticles or stomata (Geiser and Neitlich 2007; WHO 2000). Vascular plants are somewhat less sensitive to SO_2 emissions than lichens; however, several shrubs common in the LAA are affected by SO_2, including dwarf birch (*Betula glandulosa)*, bog blueberry (*Vaccinium uliginosum*), and cowberry (*Vaccinium vitis-idaea)* (Legge et al. 1998).

Nitrogen Oxides (NO_x)

Nitrogen oxides can promote plant growth when added in low concentrations; however, high concentrations can result in injury to the tissue, changes in biomass production and increased susceptibility to secondary stress factors (Graham et al. 1997). Changes in nitrogen levels deposited on the landscape can create changes in competitive relationships among species, which can result in a loss of biodiversity (Graham et al. 1997).

Dust Deposition

Dust deposition can directly and indirectly affect vegetation quality. Project components that will generate dust include on-land construction, mining, milling, general services, transportation, and on-land decommissioning.

Dust deposition can directly affect vegetation quality by covering the vegetation surface. Dust cover on non-vascular plants like mosses and lichens can cause stress and inhibit their natural cycle. Dust can absorb water from non-vascular plants, thereby increasing evaporation while restricting gas exchange and blocking active light for photosynthesis (Spatt and Miller 1981). Excess nutrient intake caused by dust on non-vascular plants can become toxic (Auerbach et al. 1997). This in turn can cause a shift in the vegetation community. For example, *Sphagnum* moss (a moss species commonly observed in a tundra environment) appears to have a low tolerance to dust deposition (Auerbach et al. 1997; NRC 2003; Spatt and Miller 1981; Walker and Everett 1987). However, other moss species appear to have a higher tolerance to dust deposition, and in some instances, total moss diversity can increase (Walker and Everett 1987). Lichens are also noted to be affected by dust deposition in areas adjacent to dust sources. Walker and Everett (1987) noted that lichen occurrence on a landscape is influenced when located within 70 m of a dust source (e.g., road). Myers-Smith et al. (2006) showed that vegetation communities subject to road dusting shifted to more grasses, sedges and cloudberry (*Rubus chamaemorus*) cover, and fewer mosses, evergreen shrubs, lichens, and forbs relative to areas not subject to dusting.

An indirect effect of dust deposition on vegetation quality involves changes in soil nutrient regime and soil pH. COPCs and other analytes can become airborne through particle suspension and be transported to areas distant from their source. Deposition of the suspended particles can cause an increase in analyte concentrations in soils, facilitating potential uptake by vegetation.

Another indirect effect of dust deposition on vegetation involves changes in surface albedo. Surface albedo refers to the ability to reflect solar radiation (Smith 1996). The less solar radiation reflected, the warmer a surface becomes. The presence of dust on a surface decreases its albedo, causing the dust-covered surface to become warmer. A decrease in surface albedo caused by dust deposition indirectly influences vegetation through its effect on snowmelt. Snowmelt occurs at a faster pace when the snowpack contains particulate matter from dust deposition, allowing earlier vegetation exposure from the snowpack. This earlier exposure could cause a change in the competitive regime among species, thereby causing an alteration in the vegetation community due to the longer growing season (Auerbach et al. 1997).

9.3.4 Mitigation Measures and Project Design for Change in Vegetation Quality

The following are mitigation measures that will be implemented to reduce Project effects on vegetation quality.

- Industrial machinery and equipment (including the diesel-powered generators) will meet federal air emission standards.
- Low sulphur diesel fuel will be used to reduce SO_2 fumigation.

- Scrubbers will be installed on exhaust stacks to remove particulates, acid mist and excess SO_2 from air emissions prior to discharge.
- Where practical, non-calcareous materials from quarry sites will be used during road construction to reduce the amount of dust-prone aggregate used.
- During open pit mining, blasting patterns will be used to control the dispersion of materials as well as dust.
- Where possible, blasting may be avoided on days where dust dispersion outside of the Project footprint is anticipated to be excessive due to the prevailing winds speeds.
- Dust suppression will occur continuously during the Project in dust-prone areas by spraying water from a tanker truck affixed with either a spray nozzle or spray bar.
- If water spraying is not effective in preventing dust occurrence, an adaptive management strategy focusing on additional dust suppression techniques will be investigated, such as using a dust suppressant identified in the GN (2002) guidelines.
- Speed limits around the mine site and along all roads will be strictly adhered to, to reduce airborne dust from vehicular and other equipment traffic.

9.3.5 Residual Effects for Change in Vegetation Quality

No residual effects on vegetation quality are predicted to occur outside of the LAAs. A description of the predicted residual effects within each LAA is provided below.

9.3.5.1 Mine LAA

The maximum predicted mean and 95th percentile for COPC concentrations that are associated with phytoxicity in lichen, browse, forage, and berries are presented in Tables 9.3-1 to 9.3-4, respectively. Predicted COPC concentrations in browse and forage species are expected to be below the minimum available phytotoxic concentrations, with the exception of zinc in browse and forage and cobalt and copper in browse (Tables 9.3-1 and 9.3-2). Baseline levels of zinc, cobalt, and copper were found to naturally occur at the upper critical level for pytotoxicity concentrations. However, there is not expected to be a significant change in the concentration of COPC in these species relative to baseline, and concentrations will not exceed upper thresholds. Therefore, no adverse effects on vegetation quality are expected to occur.

Table 9.3-1 Maximum Predicted Mean and 95th Percentile COPC Concentrations in Lichen

COPC	Units	Phytotoxic Concentration[a]		Baseline	Predicted Berry Concentrations							
					Kiggavik Camp		LSA*		RAA*		Baker Lake	
		dw	ww		Mean	95th	Mean	95th	Mean	95th	Mean	95th
U	µg/g ww	-	-	0.002	0.2	0.4	0.02	0.03	0.004	0.01	0.002	0.005
Th-230	Bq/g ww	-	-	0.002	0.004	0.009	0.002	0.006	0.002	0.006	0.002	0.005
Pb-210	Bq/g ww	-	-	0.002	0.004	0.009	0.002	0.005	0.002	0.004	0.002	0.004
Ra-226	Bq/g ww	-	-	0.0002	0.002	0.005	0.0004	0.0009	0.0003	0.0007	0.0002	0.0007
Po-210	Bq/g ww	-	-	0.001	0.003	0.006	0.001	0.002	0.001	0.002	0.001	0.002
As	µg/g ww	-	-	0.03	0.03	0.07	0.03	0.07	0.03	0.07	0.03	0.07
Cd	µg/g ww	-	-	0.02	0.04	0.08	0.02	0.05	0.02	0.05	0.02	0.05
Co	µg/g ww	-	-	0.04	0.05	0.10	0.04	0.10	0.04	0.10	0.04	0.10
Cu	µg/g ww	-	-	1.5	1.5	4.0	1.5	4.0	1.5	4.0	1.5	4.0
Pb	µg/g ww	-	-	0.06	0.07	0.2	0.06	0.2	0.06	0.2	0.06	0.2
Mo	µg/g ww	-	-	0.07	0.08	0.3	0.07	0.3	0.07	0.3	0.07	0.3
Ni	µg/g ww	-	-	0.65	0.66	2.0	0.65	2.0	0.65	2.0	0.65	2.0
Se	µg/g ww	-	-	0.004	0.004	0.012	0.004	0.012	0.004	0.012	0.004	0.012
Zn	µg/g ww	-	-	18.6	18.6	71.7	18.6	71.7	18.6	71.7	18.6	71.7

NOTE:

a = no applicable phytotoxic concentrations available for berry.

* The LAA and RAA boundaries used in the Ecological and Human Health Risk Assessment report differ from the Terrestrial Environment boundaries. See Tier 3, Appendix 8A, Section 3 for boundary clarification.

Table 9.3-2 Maximum Predicted Mean and 95th Percentile COPC Concentrations in Browse

COPC	Units	Phytotoxic Concentration		Baseline	Predicted Browse Concentrations							
					Kiggavik Camp		LSA*		RAA*		Baker Lake	
		dw	ww [a]		Mean	95th	Mean	95th	Mean	95th	Mean	95th
U	µg/g ww	-	-	0.001	0.021	0.047	0.003	0.006	0.002	0.003	0.001	0.003
Th-230	Bq/g ww	-	-	0.0003	0.0006	0.0011	0.0004	0.0007	0.0003	0.0007	0.0003	0.0007
Pb-210	Bq/g ww	-	-	0.04	0.04	0.06	0.04	0.06	0.04	0.06	0.04	0.06
Ra-226	Bq/g ww	-	-	0.001	0.0017	0.003	0.0014	0.003	0.0014	0.003	0.0014	0.003
Po-210	Bq/g ww	-	-	0.04	0.04	0.08	0.04	0.08	0.04	0.08	0.04	0.08
As	µg/g ww	3 [b]	1.4	0.19	0.2	0.8	0.2	0.8	0.2	0.8	0.2	0.8
Cd	µg/g ww	5 [b,c]	2.3	0.42	0.4	1.2	0.4	1.2	0.4	1.2	0.4	1.2
Co	µg/g ww	3 [d]	1.4	0.47	0.47	1.8	0.47	1.8	0.47	1.8	0.47	1.8
Cu	µg/g ww	25 [b]	10.5	6.5	6.6	15.3	6.6	15.3	6.6	15.3	6.6	15.3
Pb	µg/g ww	20 [d]	9.3	0.22	0.2	0.6	0.2	0.6	0.2	0.6	0.2	0.6
Mo	µg/g ww	10 [c]	4.7	0.57	0.6	2.2	0.6	2.2	0.6	2.2	0.6	2.2
Ni	µg/g ww	50 [b]	21	1.6	1.6	4.1	1.6	4.1	1.6	4.1	1.6	4.1
Se	µg/g ww	-	-	0.01	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04
Zn	µg/g ww	100 [c]	47	157	157	399	157	399	157	399	157	399

NOTES:

BOLD SHADED values exceed the phytotoxic levels.

a = dry weight (dw) concentrations converted to wet weight (ww) concentrations using an assumed moisture content of 53%.

b = Phytotoxic conc. In plant foilage. Langmuir, D., P. Chrostowski, B. Vigneault and R. Chaney 2004. Issue Paper on the Environmental Chemistry of Metals. Submitted to U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC. ERG, Lexington, MA.

c = Leaf tissue concentration in plants that are neither sensitive nor tolerant McBride, M.B. 1994 Environmental Chemistry of Soils. Oxford University Press Inc. New York, NY.

d = Upper Critical Level in leaves and shoots of spring barley associated with reduced yield. Davis, R.D., P.H.T. Beckett and E. Wollan 1978. Critical Levels of Twenty Potentially Toxic Elements in Young Spring Barley. Plant Soil 49: 395-408.

* The LAA and RAA boundaries used in the Ecological and Human Health Risk Assessment report differ from the Terrestrial Environment boundaries. See Tier 3, Appendix 8A, Figure 3.1-1 for boundary clarification.

Table 9.3-3 Maximum Predicted Mean and 95th Percentile COPC Concentrations in Forage

COPC	Units	Phytotoxic Concentration		Baseline	Predicted Forage Concentrations							
					Kiggavik Camp		LSA*		RAA*		Baker Lake	
		dw	ww [a]		Mean	95th	Mean	95th	Mean	95th	Mean	95th
U	µg/g ww	-	-	0.07	0.09	0.3	0.08	0.3	0.07	0.3	0.07	0.3
Th-230	Bq/g ww	-	-	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02
Pb-210	Bq/g ww	-	-	0.12	0.12	0.39	0.12	0.39	0.12	0.39	0.12	0.39
Ra-226	Bq/g ww	-	-	0.01	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04
Po-210	Bq/g ww	-	-	0.07	0.08	0.22	0.08	0.22	0.08	0.22	0.08	0.22
As	µg/g ww	3 [b]	1.4	0.06	0.06	0.3	0.06	0.3	0.06	0.3	0.06	0.3
Cd	µg/g ww	5 [b,c]	2.3	0.08	0.08	0.2	0.08	0.2	0.08	0.2	0.08	0.2
Co	µg/g ww	3 [d]	1.4	0.19	0.19	0.7	0.19	0.7	0.19	0.7	0.19	0.7
Cu	µg/g ww	25 [b]	10.5	2.9	2.9	7.3	2.9	7.3	2.9	7.3	2.9	7.3
Pb	µg/g ww	20 [d]	9.3	0.37	0.37	1.2	0.37	1.2	0.37	1.2	0.37	1.2
Mo	µg/g ww	10 [c]	4.7	0.78	0.78	3.0	0.78	2.9	0.78	2.9	0.78	2.9
Ni	µg/g ww	50 [b]	21	1.2	1.2	3.3	1.2	3.3	1.2	3.3	1.2	3.3
Se	µg/g ww	-	-	0.19	0.19	0.4	0.19	0.4	0.19	0.4	0.19	0.4
Zn	µg/g ww	100 [c]	47	21.3	21.4	54.5	21.4	54.5	21.4	54.5	21.4	54.5

NOTES:

BOLD SHADED values exceed the phytotoxic levels.

a = dry weight (dw) concentrations converted to wet weight (ww) concentrations using an assumed moisture content of 53%.

b = Phytotoxic conc. In plant foilage. Langmuir, D., P. Chrostowski, B. Vigneault and R. Chaney 2004. Issue Paper on the Environmental Chemistry of Metals. Submitted to U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC. ERG, Lexington, MA.

c = Leaf tissue concentration in plants that are neither sensitive nor tolerant McBride, M.B. 1994 Environmental Chemistry of Soils. Oxford University Press Inc. New York, NY.

d = Upper Critical Level in leaves and shoots of spring barley associated with reduced yield. Davis, R.D., P.H.T. Beckett and E. Wollan 1978. Critical Levels of Twenty Potentially Toxic Elements in Young Spring Barley. Plant Soil 49: 395-408.

* The LAA and RAA boundaries used in the Ecological and Human Health Risk Assessment report differ from the Terrestrial Environment boundaries. See Tier 3, Appendix 8A, Section 3 for boundary clarification.

Table 9.3-4 Maximum Predicted Mean and 95th Percentile COPC Concentrations in Berries

COPC	Units	Phytotoxic Concentration[a]		Baseline	Predicted Berry Concentrations							
					Kiggavik Camp		LSA*		RAA*		Baker Lake	
		dw	ww		Mean	95th	Mean	95th	Mean	95th	Mean	95th
U	µg/g ww	-	-	0.002	0.2	0.4	0.02	0.03	0.004	0.01	0.002	0.005
Th-230	Bq/g ww	-	-	0.002	0.004	0.009	0.002	0.006	0.002	0.006	0.002	0.005
Pb-210	Bq/g ww	-	-	0.002	0.004	0.009	0.002	0.005	0.002	0.004	0.002	0.004
Ra-226	Bq/g ww	-	-	0.0002	0.002	0.005	0.0004	0.0009	0.0003	0.0007	0.0002	0.0007
Po-210	Bq/g ww	-	-	0.001	0.003	0.006	0.001	0.002	0.001	0.002	0.001	0.002
As	µg/g ww	-	-	0.03	0.03	0.07	0.03	0.07	0.03	0.07	0.03	0.07
Cd	µg/g ww	-	-	0.02	0.04	0.08	0.02	0.05	0.02	0.05	0.02	0.05
Co	µg/g ww	-	-	0.04	0.05	0.10	0.04	0.10	0.04	0.10	0.04	0.10
Cu	µg/g ww	-	-	1.5	1.5	4.0	1.5	4.0	1.5	4.0	1.5	4.0
Pb	µg/g ww	-	-	0.06	0.07	0.2	0.06	0.2	0.06	0.2	0.06	0.2
Mo	µg/g ww	-	-	0.07	0.08	0.3	0.07	0.3	0.07	0.3	0.07	0.3
Ni	µg/g ww	-	-	0.65	0.66	2.0	0.65	2.0	0.65	2.0	0.65	2.0
Se	µg/g ww	-	-	0.004	0.004	0.012	0.004	0.012	0.004	0.012	0.004	0.012
Zn	µg/g ww	-	-	18.6	18.6	71.7	18.6	71.7	18.6	71.7	18.6	71.7

NOTE:

a = no applicable phytotoxic concentrations available for berry.

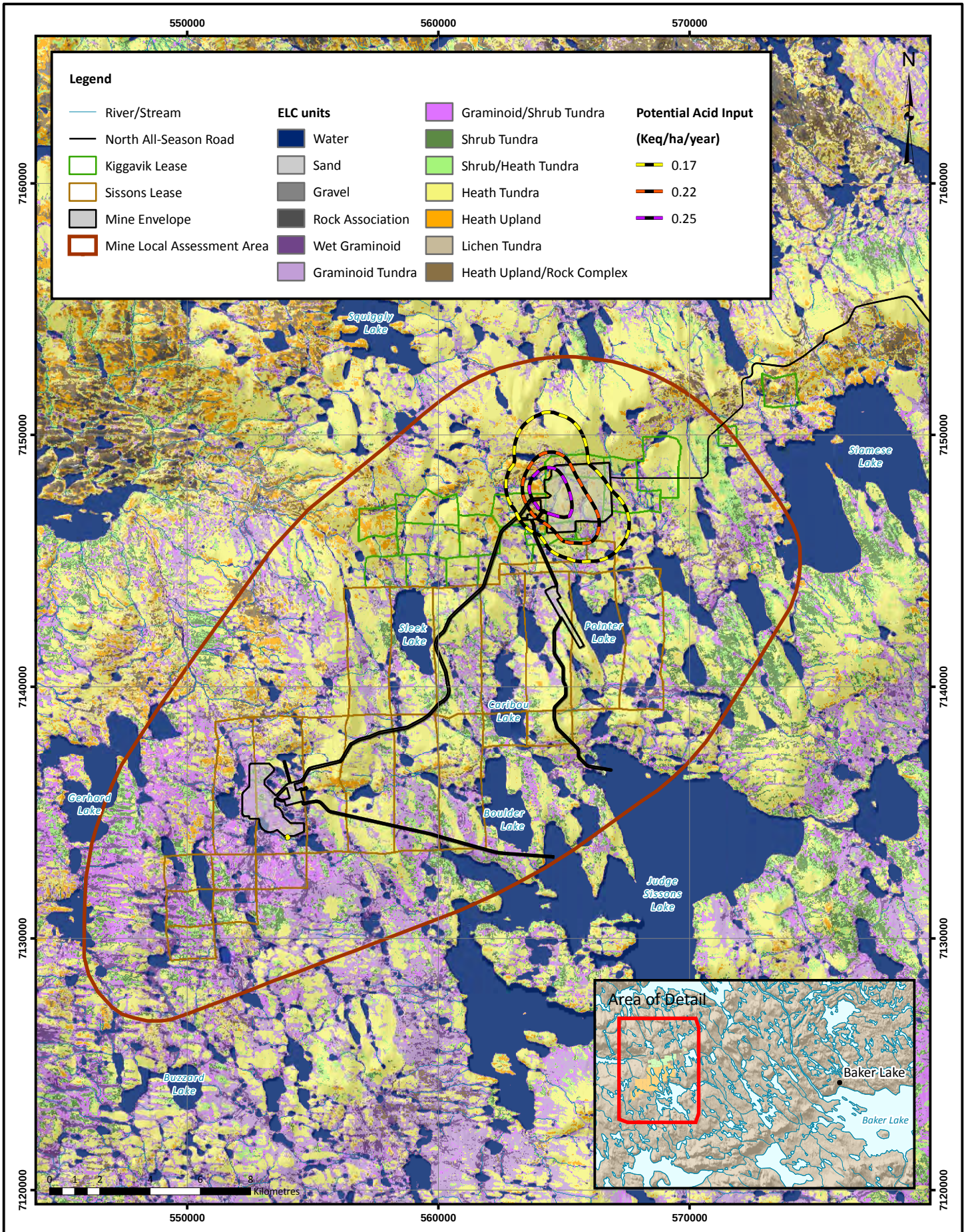
* The LAA and RAA boundaries used in the Ecological and Human Health Risk Assessment report differ from the Terrestrial Environment boundaries. See Tier 3, Appendix 8A, Section 3 for boundary clarification.

There is a lack of phytoxicity concentration values available for COPC in berries and lichen, as well as for some COPC in browse and forage. With the exception of uranium at the Kiggavik camp site, there is expected to be little change in the concentrations in browse, forage and berries between baseline values and the predicted changes in concentrations caused by the Project. In addition, all predicted soil concentrations are below the available soil quality guidelines, which are set to protect vegetation. Consequently, no change in vegetation quality is expected to occur as a result of COPC emissions from the Project.

For lichen, there is the potential for a measureable change in concentrations of several COPC at the Kiggavik camp (used to represent on-site vegetation). Unfortunately, there are no appropriate benchmarks for assessing this effect. Lichens exhibit a range of tolerances to metals. Some species of Cladonia, Peltigera, and Stereocaulon can tolerate high levels of metals and may even be found growing on mining spoils or other metal-enriched substrates (USDA Forest Service 2011). To place the results in context, the estimated lichen concentrations were compared to measurements collected from exposed areas near another uranium mine site (McClean). In general, with the exception of on-site locations, the estimated concentration is either close to baseline or within the range experienced at other sites. A formal evaluation of the health of lichen at the McClean site has not been undertaken but there is a relative abundance of reindeer lichen at exposure sites and environmental technicians at the McClean site have not reported any obvious signs of stress. Based on the available information, it is not expected that there would be widespread effects on lichen; however, it is uncertain whether there will be any effects on lichen on the Kiggavik Project site due to metal accumulation. This would not result in population-level effects. The biological mean residence time is two to five years for most elements in lichens (Walther et al. 1990); therefore, any effects on lichen are not expected to extend far beyond the life of the Project. The potential food-chain effects for animals that consume lichen are addressed in the Ecological and Human Health Risk Assessment report (i.e., Tier 3, Appendix 8A).

Based on air quality modelling, PAI values are predicted to be below 0.5 keq/ha/year (Table 9.3-5). PAI emissions generated from the Kiggavik mine site are expected to be within the threshold values of 0.17, 0.22 and 0.25 keq/ha/yr (Figure 9.3-1). A summary of the amount of ELC map units potentially exposed to the PAI emissions for each threshold value at the Kiggavik mine site is presented in Table 9.3-5. PAI values greater than 0.25 keq/ha/year are predicted to occur over 81 ha of the Kiggavik mine site. The proportion of the mine LAA potentially exposed to PAI values greater than 0.25 keq/ha/year outside of the Project footprint is approximate 0.2%.

Results of the air quality modelling indicate that PAI emissions from the Sissons mine site will be within the threshold value of 0.17 keq/ha/year. These emissions are predicted to occur near the south boundary of the Project footprint. Only about 1.6 ha outside of the Sissons mine site is expected to be exposed to PAI emissions.



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/09/2011 Scale: 1:200,000
File: 9.3-1_ELC_in_PAI_Isopleth.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, SENES Consultants Ltd. AREVA Resources Canada Inc., Gebauer & Associates.*

FIGURE 9.3-1
ECOLOGICAL LAND CLASSIFICATION UNITS
AFFECTED BY POTENTIAL ACID INPUT
AT THE KIGGAVIK AND SISSONS MINE SITES
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Table 9.3-5 ELC Map Units Located within the Predicted Potential Acid Input Isopleths at the Kiggavik Mine Site

ELC Unit	Potential Acid Input (PAI) Keq/ha/year				Proportion of Mine LAA (%)
	0.17 (ha)	0.22 (ha)	0.25 (ha)	Total (ha)	
Anthropogenic					
Disturbance	0.0	0.0	0.0	0.0	0.0
Unclassified					
Cloud/Shadow	0.0	0.0	0.0	0.0	0.0
Upland					
Sand	0.1	0.2	0.4	0.6	0.0
Gravel	3.7	3.7	2.3	9.7	0.0
Rock Association*	0.5	0.3	0.0	0.8	0.0
Graminoid Tundra*	82.5	30.9	3.1	116.6	0.3
Graminoid/Shrub Tundra*	49.9	22.9	1.4	74.2	0.2
Shrub Tundra*	25.0	10.4	0.3	35.6	0.1
Shrub/Heath Tundra*	53.8	14.1	0.2	68.1	0.2
Heath Tundra*	603.8	112.8	39.9	756.6	1.7
Heath Upland*	45.8	18.3	21.2	85.3	0.2
Heath Upland/Rock Complex*	17.4	8.0	1.6	26.9	0.1
Lichen Tundra*	25.1	10.9	4.1	40.1	0.1
Upland Total	907.6	232.5	74.4	1,214.5	2.7
Wetland					
Water	40.6	4.2	3.9	48.7	0.1
Wet Graminoid*	23.9	9.2	2.4	35.5	0.1
Wetland Total	64.5	13.4	6.3	84.2	0.2
Total Area	972.1	245.9	80.7	1,298.7	2.9

NOTE:
* - ELC units containing vegetation species that are harvested by Inuit.

Table 9.3-6 summarizes the maximum incremental concentrations of NO_2 and SO_2 from the Project relative to phototoxicity benchmarks for vegetation (WHO 2000). These results indicate that exposure to NO_2 or SO_2 is not expected to exceed these benchmark and cause adverse effects on vegetation.

Table 9.3-6 NO_2 and SO_2 Emissions Relative to Phytotoxicity Benchmarks for Vegetation

Receptor Name	NO_2 (µg/m^3)	SO_2 (µg/m^3)	
	Incremental Annual Maximum	**Incremental 24-hr Maximum**	**Incremental Annual Maximum**
Accommodation Complex	10.4	15.4	0.6
Judge Sissons Lake Cabin	0.80	0.8	0.03
Community of Baker Lake	0.04	0.04	0.001
Phytotoxicity Benchmark (µg/m^3)	19*	100	20[a] 10

NOTE:

Annual concentrations were obtained from Period 2, which had the highest SO_2 and NO_x emission rates. During this period, there is open pit mining of Main Zone West Pit at Kiggavik and Andrew Lake at Sissons as well as the milling of ores from East Zone, Centre Zone and Main Zone pits.

* The phytotoxicity value for NOx (annual average of 30 µg/m^3) has been converted to a NO_2 concentration (assuming NO_2 represents 63% of NOx) for comparison to model results.

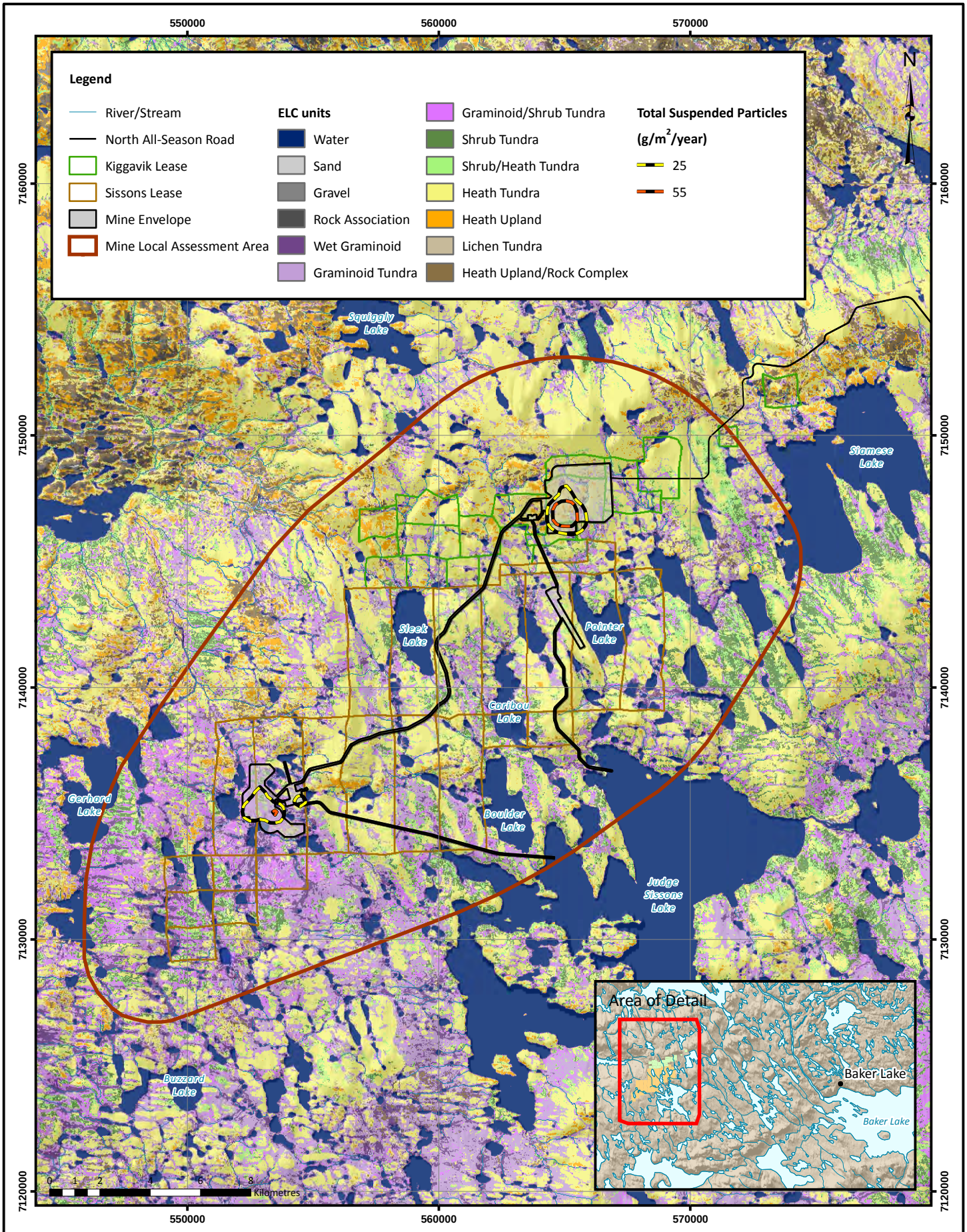
[a] 20 µg/m^3 is selected for forests and natural vegetation; 10 µg/m^3 is selected for lichen

Air quality modelling for dust deposition (i.e., Total Suspended Particle [TSP]) predicts that nuisance dust (i.e., 55 g/m^2/year) will only be generated at the Kiggavik mine site, and will likely be confined to the Project footprint (Figure 9.3-2). Dust deposition of 25 g/m^2/year is expected to be confined primarily at both the Kiggavik and Sissons mine sites; however, approximately 20 ha and 16 ha of vegetation located outside of the Project Footprint at each mine site will likely receive dust deposition at this level, respectively (see Table 9.3-7 for ELC map units to be affected). The proportion of the ELC map units located adjacent to the Project footprint that is expected to be exposed to the dust threshold level of 25 g/m^2/year is approximately 0.08%.

Based on the modelling predictions, the residual effects of PAI and dust deposition on vegetation quality within the mine LAA is anticipated to be low in magnitude during the construction and final closure phases. But, the magnitude will likely increase to moderate during operations due to an increase in Project activities associated with open pit mining and vehicular movement (e.g., ore haul trucks) within the open pits and around the mine sites.

Residual effects of PAI and dust deposition on vegetation quality are anticipated to be long term, but the residual effects will be reversible when Project activities that generate acidifying air emissions and dust are discontinued.

Project residual effects associated with COPC, NO_2, and SO_2 concentrations on vegetation quality are anticipated to be low in magnitude but have the potential to be regional in geographic extent. These residual effects are likely to occur during the construction, operation and final closure phases of the Project and are expected to be long term in duration. However, the residual effects will be reversible following discontinuation of Project activities.



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/09/2011 Scale: 1:200,000
File: 9.3-2_ELC_in_TSP_Isopleth.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, SENES Consultants Ltd. AREVA Resources Canada Inc., Gebauer & Associates.*

FIGURE 9.3-2
ECOLOGICAL LAND CLASSIFICATION UNITS AFFECTED BY TOTAL SUSPENDED PARTICLES AT THE KIGGAVIK AND SISSONS MINE SITES
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Table 9.3-7 ELC Map Units Located within the Predicted Total Suspended Particulate Matter Isopleths

ELC Unit	Total Suspended Particulate Matter (TSP) g/m^2/year					
	Kiggavik Mine Site			Sissons Mine Site		
	25	55	Total	25	55	Total
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
Anthropogenic						
Disturbance	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified						
Cloud/Shadow	0.0	0.0	0.0	0.0	0.0	0.0
Upland						
Sand	0.0	0.0	0.0	0.0	0.0	0.0
Gravel	0.4	0.0	0.4	0.1	0.0	0.1
Rock Association*	0.0	0.0	0.0	0.0	0.0	0.0
Graminoid Tundra*	0.6	0.0	0.6	2.4	0.0	2.4
Graminoid/Shrub Tundra*	1.7	0.0	1.7	2.0	0.0	2.0
Shrub Tundra*	3.0	0.0	3.0	0.1	0.0	0.1
Shrub/Heath Tundra*	3.1	0.0	3.1	0.3	0.0	0.3
Heath Tundra*	9.9	0.0	9.9	4.8	0.0	4.8
Heath Upland*	0.4	0.0	0.4	0.6	0.0	0.6
Heath Upland/Rock Complex*	0.1	0.0	0.1	0.1	0.0	0.1
Lichen Tundra*	0.5	0.0	0.5	0.4	0.0	0.4
Upland Total	19.7	0.0	19.7	10.9	0.0	10.9
Wetland						
Water	0.0	0.0	0.0	2.2	0.0	2.2
Wet Graminoid*	0.0	0.0	0.0	3.1	0.0	3.1
Wetland Total	0.0	0.0	0.0	5.2	0.0	5.2
Total Area	19.7	0.0	19.7	16.1	0.0	16.1

9.3.5.2 Road LAAs

Air quality modelling of dust deposition associated with the North All-Season Road predicts a rate of less than 0.1 g/m^2/year. Dust deposition associated with the winter roads is expected to be less than the North All-Season Road, as the amount of dust generated by vehicle traffic on a frozen ground surface will be negligible. Because of the low rates of dust deposition associated with the access roads, COPC concentrations in vegetation are predicted to be below concentrations predicted for the mine LAA, and they are negligible.

Predicted maximum incremental NO_2 and SO_2 concentrations for each of the proposed access road options are presented in Table 9.3-8. The predicted concentrations are below the threshold values for vegetation (Section 9.1.4). Therefore, the residual effects on vegetation quality—due to increases in NO_2 and SO_2 concentrations along each proposed access road—are anticipated to be negligible.

Table 9.3-8 Overall Maximum NO_2 and SO_2 Concentrations Predicted for Access Road Options

Access Road Option	Overall Maximum Incremental Concentration					
	NO_2 ($\mu g/m^3$)			SO_2 ($\mu g/m^3$)		
	1-hr Maximum	24-hr Maximum	Annual	1-hr Maximum	24-hr Maximum	Annual
North All-Season Road	1.40E-01	7.00E-02	8.80E-03	1.00E-02	5.40E-03	6.70E-04
North Winter Road	8.40E-01	4.80E-01	2.80E-02	7.30E-02	4.10E-02	2.40E-03
South Winter Road	6.50E-01	4.30E-01	1.70E-02	5.60E-02	3.70E-02	1.40E-03
Air Quality Criteria ($\mu g/m^3$)	400	200	100	450	150	30

NOTES:

NO_2 AQ criteria adopted from the Government of NWT (2011) Natural Resources Guideline for Ambient Air Quality Standards.

SO_2 criteria based on GN (2002) Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates.

9.3.5.3 Dock Site Options

Predicted incremental increases in concentrations of TSP, NO_2 and SO_2 as a result of the dock facility are presented in Table 9.3-9. Predicted concentrations for NO_2 and SO_2 are below the World Health Organization (WHO) threshold values for vegetation (Section 9.1.4). Similarly, predicted concentrations for TSP are below the threshold values identified in the Government of Nunavut's (2002) Environmental Guideline for Air Quality – Sulphur Dioxide and Suspended Particulates. Further details regarding TSP are presented in the Atmospheric Environment (Tier 2, Volume 4). Based on the air quality modelling predictions for the preferred dock site option, residual effects on vegetation quality are anticipated to be low in magnitude and local in geographic context. These residual effects will likely occur during construction, operation and final closure, and will be long term in duration but reversible following discontinuation of Project activities.

Table 9.3-9 Incremental Concentrations Predicted for the Preferred Dock Site Option

Receptor	Incremental Concentration							
	TSP ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)			SO_2 ($\mu g/m^3$)		
	24-hour Maximum	Annual	1-hour Maximum	24-hour Maximum	Annual	1-hour Maximum	24-hour Maximum	Annual
Dock Site Option	8.80E-01	7.70E-05	59.86	11.7	0.19	5.51	1.11	0.02
Air Quality Criteria ($\mu g/m^3$)	120	60	400	200	100	450	150	30

NOTES:

TSP and SO_2 criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.

NO_2 criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.

9.3.6 Determination of Significance for Change in Vegetation Quality

Change in vegetation quality due to air emissions and dust deposition during Project construction and operation activities is predicted to be not significant. This is based on the following facts:

- There will be little change from measured baseline concentrations in browse, forage and berries within the LAAs.
- Only 0.2% the mine LAA outside of the Project footprint will potentially be exposed to PAI values in exceedance of the threshold level.
- NO_2 and SO_2 concentrations are predicted to be below threshold values.
- Most dust deposition will occur within the confines of the Project footprint.
- Only 0.08% of the ELC map units located adjacent to the Project footprint are expected to be exposed to the dust threshold level of 25 g/m^2/year.

Overall, confidence in this prediction is considered moderate. While the effects of air emissions on most vegetation types is relatively well understood, and the effectiveness of mitigation measures is well documented, no established thresholds exist for determining the effects of dust deposition on vegetation quality.

Prediction confidence will be improved through specific monitoring programs that will occur throughout the Project (dust and air emissions, vegetation sampling for analyte concentrations from permanent sampling plots).

9.3.7 Compliance and Environmental Monitoring for Change in Vegetation Quality

Compliance and environmental monitoring for change in vegetation quality will include the following:

- Permanent sampling plots will be established adjacent to the Project Footprint, and vegetation samples will be collected and analyzed to determine changes in analyte concentrations.
- Air quality monitoring stations will be established within the mine LAA and will be routinely surveyed to measure potential changes in NO_2, SO_2, and analytes. Results from these stations will be compared to analyte concentrations in vegetation from the permanent sampling plots.
- Dust deposition stations will be established adjacent to the mine footprint, as well as the access roads. Monitoring of these stations will commence prior to construction activities and will continue throughout the duration of the Project. Results from these stations will be compared to analyte concentrations in vegetation from the permanent sampling plots.

9.4 CUMULATIVE EFFECTS ANALYSIS FOR VEGETATION

9.4.1 Screening for Cumulative Environmental Effects

Of the potential future projects and activities identified in the Project Inclusion List (Tier I, Volume 1), only the Meadowbank dock site facility has the potential to interact with the Project. The Meadowbank dock facility is located approximately 1 km from the preferred dock site (Option #1). Both construction and operation activities at the Project dock facility could overlap temporally with operation of the Meadowbank dock and potentially cause cumulative effects on vegetation quality as a result of increased air emissions.

An air quality assessment was completed as part of the Atmospheric Environment Assessment (Tier 2, Volume 4) to determine potential cumulative effects from the combined operations of the Meadowbank and Kiggavik dock and storage facilities. Result of the modelling predicted exceedances of the 1-hour and 24-hour threshold values for ambient NO_2 concentrations during periods when both facilities are operating simultaneously. The exceedances are predicted to occur approximately 1 % of the time annually and are expected to be localized. While this NO_2 deposition could result in a decrease in vegetation quality, this would represent only a fraction of the ambient NO_2 concentrations, which are unlikely to cause a detectable change in vegetation quality.

No other projects were identified within the RAA. However, exploration activities are currently occurring near the proposed Project (Tanqueray option, Ukaliq, Schultz Lake, St. Tropez Claims, Judge Sissons, and Kiggavik S. exploration sites). As such, these activities are considered as part of the Base Case, and have been addressed in the context of current baseline conditions for soils.

None of the exploration projects located within the RAA is involved in the regulatory process, or has made a public announcement to seek regulatory approval. The effects of these exploration activities on vegetation are likely to be localized to the exploration site, and are not anticipated to overlap with the residual effects from the Kiggavik Project. As well, no other projects or developments are known to occur and no future projects are anticipated within the LAA and RAA boundary. As the Project effects are not expected to extend beyond the LAA or overlap with any other projects, no cumulative effects on vegetation are anticipated. As a result, the cumulative effect of changes in vegetation abundance, quality and community diversity is not considered further in this assessment.

9.5 SUMMARY OF PROJECT RESIDUAL ENVIRONMENTAL EFFECTS ON VEGETATION

Project residual effects on vegetation abundance and community diversity, and vegetation quality are predicted to be not significant (Table 9.5-1). During construction, Project activities associated with site clearing and burial of vegetation will be restricted within the confines of a pre-surveyed Project footprint area. Depending on the Project development option, the disturbed area will range between 1.1% and 1.4% of the combined LAAs. Approximately 168 ha to 175 ha (i.e., 0.4% to 0.5%, respectively) of the wetland area within the LAA boundaries that supports vegetation is expected to be lost. Heath tundra will be most affected, with a decrease in abundance representing between 1.9% and 2.8% of the total area, depending on the Project development option combination selected. Air emissions generated by the Project components will change the analyte concentrations in vegetation; however, the majority of the predicted changes are within the threshold values, except for zinc, cobalt, and copper where baseline levels were found to naturally occur at the upper critical level for phytoxicity concentrations. Changes in these analyte concentrations are not anticipated to exceed upper thresholds; therefore, no adverse effects on vegetation quality are expected to occur. PAI levels greater than the critical load threshold value are predicted to occur over 81 ha adjacent to the Kiggavik mine site, affecting approximately 0.2% of the mine LAA and resulting in a negligible residual effects on vegetation. No residual effects from NO_2 and SO_2 concentrations on vegetation are anticipated to occur, as generated emissions are predicted to be below threshold values. Effects of dust deposition on vegetation are anticipated to be local, representing only about 36 ha adjacent to the Kiggavik and Sissons mine sites. Dust deposition along the proposed access roads is anticipated to be negligible, with a predicted annual deposition of 0.1 g/m^2.

The residual effects for vegetation are based on considering effects as isolated influences basis (e.g., PAI alone, changes in COPC concentrations alone). Combined interactions and potential changes are complex and difficult to understand, and no clear interaction mechanism has been found in the literature. Based on professional judgment, the combination of Project-related effects are anticipated to be no greater than the residual effects of each effect acting alone. Also, these effects are assessed on a conservative basis. Therefore, the combined Project-related effects on vegetation are predicted to be not significant.

9.5.1 Effects of Climate Change on Vegetation

Climate change could influence the effect of the Project on vegetation. An earlier snow-melt that extends the growing season due to temperature increases can accelerate any potential changes in vegetation abundance and community diversity caused by the Project. While changes in vegetation composition from a tundra sedge community to either a graminoid or shrub community in areas adjacent to human development have been documented, climate change has the potential to facilitate and accelerate this change. Hollister (2003) found a general increase in graminoid and shrub cover, with a decrease in cover of mosses and lichens. This change in cover was assumed to be caused by climate change. Modelling studies completed by Hinzman et al. (2005) assumed that changes in vegetation communities in the Arctic have the potential to influence climate, and the magnitude of the effect will depend on the temporal and spatial patterns of land cover change.

Climate change may also provide more favourable growing conditions for non-native species, especially in areas disturbed by the Project. While non-native species that are inadvertently introduced by the Project may not establish and proliferate due to the adverse conditions that currently occur, climate change may facilitate changes in conditions that promote their growth. The introduction of non-native species could potentially out-compete native species for limited resources, creating a change to the vegetation community and potentially increasing species richness (Johnson 2008; Walther et al. 2002).

Table 9.5-1 Summary of Project Residual Environmental Effects: Vegetation

Project Phase	Mitigation/ Compensation Measures	Residual Environmental Effect (Y/N)	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
				Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in vegetation abundance and community diversity: Site clearing and vegetation burial during construction will affect vegetation abundance and community diversity													
Construction	Activities confined within the work area boundaries.	Y	A	L	S	LT	O	R	ND	N	N/A	H	Environmental monitoring during construction.
Change in vegetation quality: Dust created by Project activities will affect vegetation quality													
Construction	Dust suppression by spraying water or other approved substance on travel area.	Y	A	L	L	LT	C	R	ND	N	N/A	M	Monitoring of vegetation permanent sampling plots located around the mine sites and access roads for changes in vegetation abundance and community diversity.
Operation	Avoid blasting on days when winds are excessive.	Y	A	M	L	LT	C	R	ND				
Final Closure	Reduced speed limits in dust-prone areas.	Y	A	L	L	LT	C	R	ND				Dust deposition monitoring around the mine sites as well as the access roads.
Change in vegetation quality: Air emissions from Project components will affect vegetation quality													
Construction	All industrial machinery and equipment (including the diesel-powered generators) will meet federal air emission standards.	Y	A	L	R	LT	C	R	ND	N	N/A	M	Monitoring of vegetation permanent sampling plots located around the mine sites and access roads for changes in vegetation quality.
Operation													
	Use of low sulphur diesel fuel.												
Final Closure													Monitoring of air emissions from static emissions sources associated with the Project (e.g., acid plant).
	Scrubbers installed on mill stacks to remove particulates and contaminants before discharge into the atmosphere.												
Post Closure													

Table 9.5-1 Summary of Project Residual Environmental Effects: Vegetation (cont'd)

KEY

Direction:

P Positive

N Neutral

A Adverse

Magnitude:

N Negligible: no measureable change in vegetation abundance and community diversity, or vegetation quality.

L Low: effect is detectable but within the range of natural variation or baseline values.

M Moderate: effect is detectable and outside the range of natural variation or baseline values, but is unlikely to change vegetation abundance and community diversity, or vegetation quality

H High: effect is detectable and outside the range of natural variation or baseline values leading to a change in vegetation abundance and community diversity, or vegetation quality.

Geographic Extent:

S Site-specific: (i.e., Project Footprint)

L Local (i.e., within the LAA)

R Regional (i.e., extends beyond the LAA but within the RAA)

Duration:

ST Short term: change no longer detectable at the end of construction

MT Medium term: change no longer detectable at the end of final closure

LT Long term: change extends beyond the life of the Project

Frequency:

O Once.

S Sporadically: occurs more than once, but at unpredictable intervals

R Regularly: occurs repeatedly at regular intervals

C Continuous: occurs continuously throughout the Project

Reversibility:

R Reversible

I Irreversible

Environmental Context:

D Disturbed: area has been substantially disturbed previously by human development, or human development is still present.

N Not Disturbed: area has not been disturbed by human activity.

N/A Not Applicable

Significance:

S Significant

N Not Significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood:

Of a significant effect occurring

N/A Not applicable

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Cumulative Effects

Y Potential for effect to interact with other past, present or foreseeable projects or activities

N Effect will not or is not likely to interact with other past, present or foreseeable projects or activities

9.6 SUMMARY OF MITIGATION MEASURES FOR VEGETATION

Mitigation measures that will be implemented to reduce the Project effects on vegetation are described below.

9.6.1 Vegetation Quantity

Pre-construction surveys will be completed of the surveyed Project footprint boundaries for listed species to confirm their absence from the area to be disturbed. If any listed species are observed, a number of mitigation measures may be employed. For any listed species observed along the proposed access roads, efforts will be made to re-route the access to avoid disturbing the listed species. If listed species are observed within the proposed mine sites or dock facility, AREVA will consult with the GN regarding transplanting the listed species to another suitable location.

Best management practices will occur during construction of the Project. Construction activities will likely be postponed during large precipitation events to prevent excessive disturbance to vegetation and soils due to wet working conditions.

Site clearing and vegetation burial will occur within the confines of the Project footprint to reduce the potential for additional vegetation loss and prevent unnecessary disturbance to vegetation adjacent to the Project development area. The work area boundaries will be clearly identified by markers placed along the perimeter of the work area during construction to reduce vegetation damage and disturbance.

During topsoil stripping and stockpiling, the vegetation seedbank will also be preserved. Preservation of this seedbank will provide seeds and propagules during soil replacement, facilitating natural regeneration of native vegetation to reclaimed areas.

The proposed routing of the winter roads makes use of waterbodies (e.g., lakes) and watercourses (e.g., streams) as much as possible. Rugged microtopography will be avoided, where practical, along the proposed North Winter Road to reduce the amount of granular material required for creating a level travel surface that would cause vegetation burial. Rig matting may also be used in areas where the use of granular material is not practical to prevent damage to the underlying vegetation along the North Winter Road.

To prevent the introduction of invasive and non-native vegetation to the Project area, all equipment and machinery will be cleaned of foreign particles (e.g., soil, thatch) prior to initial transport to the Project (i.e., prior to loading onto the barge, or shipping by air). All equipment and machinery will be further inspected for foreign particles upon arriving at either the dock facility or while being off-loaded at the airstrip. Any foreign particles found on equipment and machinery will be removed, collected, and incinerated to prevent propagule establishment and proliferation.

Progressive reclamation will occur throughout the Project on decommissioned areas to return disturbed areas to a natural state. Adaptive management strategies, based on the most recent research and literature pertaining to reclamation of disturbed areas in arctic environments, will be implemented and monitored for succession and to assess whether further reclamation efforts are necessary.

9.6.2 Vegetation Quality

Air emissions that could adversely affect vegetation quality will occur throughout the duration of the Project. To reduce the effects of air emissions on vegetation, all industrial machinery and equipment and diesel-powered generators will meet the federal air emission standards. Low sulphur diesel fuel will be used to reduce SO_2 fumigation. The acid plant will be the largest producing unit of SO_2 associated with the Project. As such, a scrubber will be installed on the exhaust stack to remove particulates, acid mist and excess SO_2.

Dust will be created from such activities such as blasting, hauling of ore and waste rock materials from the mine pits, as well as vehicular traffic along the access roads. During the detailed design of the roads, efforts will be made to use non-calcareous materials from quarry sites, which will reduce dust-prone aggregate from being used during road construction. During open pit mining, blasting patterns will be used to control the dispersion of materials as well as dust. Where possible, blasting may also be avoided on days where dust dispersion outside of the Project footprint is anticipated to be excessive due to the prevailing winds speeds. Dust suppression will involve spraying water from a tanker truck affixed with either a spray nozzle or spray bar onto dust-prone areas. If water spraying is not effective in preventing dust occurrence, an adaptive management strategy focusing on additional dust suppression techniques will be investigated, such as using a dust suppressant identified in the GN (2002) guidelines. Speed limits around the mine site and along all roads will be strictly adhered to, to reduce airborne dust from vehicular and other equipment traffic.

9.7 SUMMARY OF COMPLIANCE AND ENVIRONMENTAL MONITORING FOR VEGETATION

A summary of compliance and environmental monitoring for vegetation that will occur during the Project are described below.

9.7.1 Vegetation Quantity

An environmental monitor will be on-site during all phases of the Project to work with AREVA personnel and contractors to meet and comply with environmental regulations associated with vegetation.

Throughout the duration of the Project, monitoring for invasive species will be completed. Any invasive species identified adjacent to the Project footprint will be documented. If invasive species are identified as noxious weeds, or other vegetation species that are suspected of competing with native vegetation, efforts will be made to remove these occurrences to prevent a spread or proliferation of these invasive species.

Measurements of dust deposition from snow survey stations and dust gauges placed around the Project Footprint and along the proposed access roads will be taken prior to construction activities. Permanent sampling plots to monitoring vegetation abundance and community diversity will also be established around the Project Footprint and adjacent to the proposed access roads prior to their construction. These permanent sampling plots will be routinely surveyed and assessed to measure potential changes in vegetation abundance and community diversity. Results from dust deposition monitoring and the vegetation community monitoring will confirm the effectiveness of mitigation and determine whether further actions are required.

9.7.2 Vegetation Quality

Vegetation monitoring will occur throughout the duration of the Project, along with air emissions and dust deposition to evaluate their effects on vegetation quality. Vegetation quality monitoring will involve collection of vegetation samples from permanent sample plots located within the predicted exposure areas as determined by the isopleths for PAI and TSP within mine LAA (i.e., exposure plots), as well as reference plots located within the Project RAA. Chemical analyses of the vegetation samples will be completed and comparisons will be made between the reference and exposure site values, as well as to the baseline values and CCME guidelines.

A dust monitoring program will be undertaken to determine the amount of dust generated, and its dispersal, by the Project. The monitoring program confirm if effects are occurring on vegetation, and the results will be used to modify, if necessary, management strategies.

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11 SCOPE OF THE ASSESSMENT TERRESTRIAL WILDLIFE AND HABITAT

11.1 ISSUES AND CONCERNS IDENTIFIED DURING INUIT, GOVERNMENT AND STAKEHOLDER ENGAGEMENT

Most of the issues and concerns regarding wildlife at the stakeholder engagement and IQ sessions focused on the Project's potential interaction with caribou (*Rangifer tarandus*). Caribou were consistently mentioned as an important wildlife species due to their cultural, dietary, and economic importance to the local people. Representative comments made during the stakeholder engagement sessions regarding wildlife include:

- People want to be assured that the Project will not disturb caribou on which people are still greatly dependent. They believe that if the migration routes are affected, the caribou may move too far away for people to hunt (ARE 2009).

Numerous comments focused on the proposed access road and potential for the road to affect migration, negatively or positively affect hunting, dust created and settling on near-by vegetation that would be consumed by wildlife and also the management of the road.

- One Elder suggested that if a road is built from Baker Lake to the Kiggavik mine site, it may cause the caribou to go to Chesterfield Inlet. Another Elder pointed out that the caribou using the calving area around Josephine Lake have not been affected by the Shear Minerals camp located there (CI03, 2009; CI01, 2009).
- Participants in the young adults' focus group were concerned that Project-related roads may affect caribou migration, which in turn may require Elders to travel farther for food (RIYA 2009).
- If AREVA builds a road, it may cause changes to the caribou migration and limit hunter access (BLHT 2011).
- If AREVA builds a road, there will be dust from the road in the summer time. This dust will collect on the grass on which the caribou feed, and may affect caribou health. This should be minimized (BLHT 2011).
- A road could potentially provide better access to the caribou, but there would need to be more (three or four) wildlife monitors in place. These monitors are most useful between June and December (BLHT 2011).
- Contamination of habitat and water sources were raised in a number of meetings

- Young adults have heard about damage to the environment caused by mines and believe the effect assessment should consider the potential effects of the Project during all seasons. They also believe priority should be given to considering potential effects of the Project on caribou migration routes (RIYA 2009).
- HTO members are concerned about caribou that may get too close to the mine causing potential contamination to the caribou (RBHT 2009).
- Community members emphasized that AREVA will need to keep the caribou out of danger and to educate people about the potential dangers from a uranium mine (WCE 2009).
- Whale Cove Elders are aware there have been problems at other mines and cited instances of caribou eating harmful things at mine sites (WCE 2009).
- Women said they were concerned about the potential effects of the Project on water, wildlife, caribou, and on the air in particular (RIW 2009).
- Hunters and elders expressed concerns about the potential for airborne contamination settling on vegetation and being consumed by caribou (ARHT 2009).

Other terrestrial wildlife species were mentioned but with much less frequency than caribou.

- Everyone is concerned about birds that migrate past Baker Lake (RBE 2009).

11.2 INFLUENCE OF INUIT AND STAKEHOLDER ENGAGEMENT ON THE TERRESTRIAL WILDLIFE ASSESSMENT

Prior to baseline field studies, available IQ was collected to determine current and historical presence of wildlife species in and around the Kiggavik Project and to identify areas of special concern in the Project LAAs and RAA. The information sources included informal discussions with Hunter and Trappers Organizations (HTOs), community leaders, local area residents and hunters. The IQ was useful in identifying VECs of greatest importance to hunters and residents, prioritizing field programs and defining the final boundaries of the RAA to encompass known caribou use areas.

IQ from 2008 and 2009 interviews and focus group discussions in Baker Lake and nearby communities was reviewed and incorporated into the Terrestrial Wildlife Baseline Report. The IQ provided additional evidence on wildlife presence, behaviour, and habitat use to supplement and inform historical and regional data, as well as current data from the 2007 to 2010 field surveys. In particular, information on important caribou use areas (i.e., water crossings, calving and post-calving areas, and areas of migration), and historical and current presence and use of caribou, other mammals and birds provided valuable insight to the terrestrial wildlife dataset.

The terrestrial wildlife assessment is based largely on information collected during IQ studies, concerns raised by community members (e.g., hunters) and personnel from local organizations, including the HTO and Hamlet of Baker Lake, and data collected during IQ-directed field studies from 2007 through 2010.

11.3 INFLUENCE OF INUIT QAUJIMAJATUQANGIT ON THE TERRESTRIAL WILDLIFE ASSESSMENT

Inuit Qaujimajatuqangit has been fundamental in selection of VECs for the terrestrial wildlife assessment, and identification of potential Project effects. Specifically, it has highlighted concern regarding the sensitivity of terrestrial wildlife to road traffic in the region, and the importance of year-round harvesting of caribou in providing food and clothing for local communities (CHE 2009). These issues and concerns have been considered in scoping of the terrestrial wildlife assessment.

11.4 REGULATORY SETTING

11.4.1 Nunavut Wildlife Act

The *Nunavut Wildlife Act* is territorial legislation established for the management of wildlife and habitat in Nunavut, including the conservation, protection and recovery of species at risk. The Act applies to all terrestrial and aquatic wildlife and their habitat. The Department of Environment Wildlife Management Division has a legislated mandate for the management of terrestrial species in Nunavut and is responsible for fulfilling GN responsibilities under federal legislation, and national and international agreements and conventions.

11.4.2 Species at Risk Act

SARA is federal legislation that “provides for the legal protection of wildlife species and the conservation of the biological diversity” (SARA website). SARA is designed to prevent the extirpation and/or extinction of wildlife species through formal protection measures identified through a species recovery planning process. The plans are designed to identify actions that will lead to the recovery of species of conservation concern. Schedule 1 of SARA lists the status of species of conservation concern under four risk categories: extirpated, endangered, threatened, and species of special concern. Once a species is listed on Schedule 1 of SARA, individuals of these species are protected from “killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling or trading” (SARA website). Recovery or management plans are required for listed species.

Under SARA, persons/organizations who are “required by or under an Act of Parliament to ensure that an assessment of the environmental effects of a project is conducted” must inform the competent minister if a project “is likely to affect a listed wildlife species” (Subsection 79[1]); and those persons/organizations are required to “identify the adverse effects of the project on the listed wildlife species and its critical habitat and, if the Project is carried out, must ensure that measures are taken to avoid or lessen those effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategy and action plans” (Subsection 79[2]).

11.4.3 Migratory Birds Convention Act

The *Migratory Birds Convention Act* provides “for the protection [and conservation] of migratory birds through the Migratory Birds Regulations”. The acts protects migratory populations, individuals and their nests (1994, c. 22, s. 4; 2005, c. 23, s. 3) through prohibition of:

- possession of a migratory bird or nest
- the purchase, sale or exchange of migratory birds or nests
- deposition of substances into waters that is harmful to migratory birds, or in a location where the substance can enter waters, without appropriate authorizations

11.4.4 Nunavut Land Claims Agreement

Under the NLCA, the government has the ultimate responsibility for wildlife. The GN Department of the Environment is the lead GN Agency in fulfilling Government obligations with respect to wildlife in Nunavut.

The Nunavut Wildlife Management Board (NWMB) is the main instrument of wildlife management and the main regulator of access to wildlife in Nunavut. Among the functions of the Board is the establishment, modification or removal of total allowable harvest (TAH) levels.

The exercise of harvesting by Inuit is overseen by the Regional Wildlife Organizations (RWO) and the HTO. Powers and functions of the HTO include regulation of harvest technique, allocation and enforcement of community basic needs and management among members.

11.4.5 Keewatin Regional Land Use Plan

The NPC was established under the NLCA and is responsible for land use planning in the NSA.

The Keewatin Regional Land Use Plan was submitted by the NPC to the Minister of AANDC and the Minister of the GN, Department of Environment (GN). The respective federal cabinet and territorial executive council approved the plan in June 2000; it is currently the land use plan in effect. Objectives of the plan that address mineral exploration in relation to wildlife state:

- The environment, wildlife and wildlife habitat should be protected and conserved for the use of future generations (Section 2).
- Non-renewable resource development should have no significant adverse effects on the environment, wildlife or wildlife habitat (Section 3).

Terms applicable to terrestrial wildlife state:

- Development activities shall be prohibited on all public lands and water within all caribou calving areas during calving season and within caribou water crossings in the Keewatin, in accordance with the terms of the DIAND caribou protection measures (Subsection 2.6).
- Development activities shall be restricted near polar bear denning areas (Subsection 2.7).

11.4.6 Caribou Protection Measures

Caribou Protection Measures (DIAND 1978, Appendix H of Keewatin Land Use Plan) apply to the Kiggavik Project. The protection measures restrict:

- activities, without approval, between 15 May and 15 June within the caribou protection areas as depicted on the 1978 ‘Caribou Protection Map
- locate any operation that will block or divert seasonal migrations
- activities that will interfere with seasonal migrations must cease until migrating caribou have passed
- activities within 10 km of designated caribou water crossings from 15 May and 1 September

11.5 PROJECT–ENVIRONMENT INTERACTIONS

The Kiggavik Project activities have the potential to interact with terrestrial wildlife during the construction, operation and decommissioning phases. A summary of relevant Project activities and a description of the associated environmental interactions are included in Table 11.5-1.

If there is no interaction or no potential for substantive interaction between a Project activity and terrestrial wildlife to cause a potential environmental effect, an assessment of that environmental effect is not required. These interactions are categorized as 0, and are not considered further in the EA. The environmental effects of these activities are thus, by definition, rated not significant.

If there is likely to be a potential interaction between a Project activity and terrestrial wildlife but not likely to be substantive in light of planned mitigation, the interaction is categorized as 1. Such interactions are well understood and are subject to prescribed mitigation or codified practices. These interactions are subject to a less detailed environmental effects assessment and are rated as not significant. Justification is provided and the proposed mitigation is described for such categorizations. Such interactions can be mitigated with a high degree of certainty with proven technology and practices.

If a potential interaction between a Project activity and terrestrial wildlife could result in more substantive environmental effects despite the planned mitigation, if there is less certainty regarding the effectiveness of mitigation, or if there is high concern from regulatory agencies, Inuit or stakeholders, the interaction is categorized as 2. These potential interactions are subject to a more detailed analysis and consideration in the environmental assessment in order to predict, mitigate and evaluate the potential environmental effects.

A rank of 1 is applied to Project components where there is an obvious interaction, but based on evidence and standard mitigation techniques, will result in an effect that is not significant (e.g., infrequent blasting), or where there is an indirect effect (noise) from building construction. Generally, the site clearing and preparation of a site is considered the Project component that directly interacts with terrestrial wildlife. A rank of 1 is applied to further construction activities (e.g., construct building, install equipment) because there is no conceivable, measurable interaction of on-site activities once the primary disturbances have occurred. Sensory disturbances associated with these activities are temporary, and effects are expected to be not measurable. This applies to on-land construction, supporting activities, water and waste management, general services, transportation, on-going exploration, closure and post closure activities. Crushing and grinding are expected to create a continual sensory disturbance of noise and dust (and thus ranked 2), but other activities associated with milling, such as “transfer ore to mill” will have an undetected effect relative to the crushing and grinding. Activities such as freshwater withdrawal for In-water construction is not expected to have a measurable effect on terrestrial wildlife or birds because standard operating procedures will be followed within water licence limits. Maintaining water levels during operations water management activities will interact with waterfowl habitat, but water level management in those waterbodies will have been addressed as a direct interaction from sensory disturbance of overall on-site Project activities. On-land decommissioning activities, such as blasting, can readily be mitigated by conducting the activities outside of sensitive wildlife periods (e.g., blasting outside of the breeding bird window, cease activities when caribou are present as per Caribou Protection Measures).

The wildlife assessment focused on Project activities that could cause a change to the traditional movements of migrating animals, result in increased mortality, cause loss of important habitat (e.g., calving grounds) due to Project footprint, or result in functional loss of habitat from sensory disturbance (e.g., visual and auditory stimuli). The bird assessment is focused on activities that could cause a reduction in recruitment due to increased nest depredation or abandonment, a loss of important habitat (e.g., nesting or fledging sites) from the Project footprint, or a functional loss of habitat from sensory disturbance.

Project activities that could cause exposure of wildlife and birds to COPC are those that produce dust, discharge water or emissions containing COPCs. Most of the potential effects will occur near the mine site during operation. Other sources of potential effects are dust generation along the North All-Season Road, and emissions from the Baker Lake facility generator.

Table 11.5-1 Project-Environment Interactions: Terrestrial Wildlife

	Project Activities	Terrestrial Wildlife and Habitat	Raptors and Habitat	Migratory Birds and Habitat	Species at Risk
Construction					
Economic Activities	Construction workforce management; Contracts and taxes; Advance training of operations workforce	0	0	0	0
In-Water Construction	Construct freshwater diversions and site drainage containment systems (dykes, berms, collection ponds)	0	0	2	0
	Construct in-water/shoreline structures	0	0	2	0
	Water transfers and discharge	0	0	0	0
	Freshwater withdrawal	0	0	1	0
On-Land Construction	Site clearing and pad construction (blasting, earth moving, loading, hauling, dumping, crushing	2	2	2	2
	Construct foundations	1	0	1	1
	Construct buildings	1	0	1	1
	Install equipment	1	0	1	1
	Install and commission fuel tanks	0	0	0	0
	Mill dry commissioning (water only)	0	0	0	0
Supporting Activities	Transport fuel and construction materials	2	2	2	2
	Air transport of personnel and supplies	2	1	2	2
	Hazardous materials storage and use	0	0	0	0
	Explosives storage and use	2	0	0	2
	Waste incineration and disposal	0	0	0	0
	Industrial machinery operation	1	0	1	1
	Power generation	1	0	1	1

Table 11.5-1 Project-Environment Interactions: Terrestrial Wildlife (cont'd)

	Project Activities	Terrestrial Wildlife and Habitat	Raptors and Habitat	Migratory Birds and Habitat	Species at Risk
Operation					
Economic Activities	Workforce management; Employment; Contracts and taxes	0	0	0	0
Mining	Mining ore (blasting, loading, hauling)	2	2	2	2
	Ore stockpiling	1	0	1	1
	Mining special waste (blasting, loading, hauling)	2	0	1	1
	Special waste stockpiling	0	0	0	0
	Mining clean waste (blasting, loading, hauling)	2	0	1	1
	Clean rock stockpiling	0	0	0	0
	Mine dewatering	0	0	0	0
	Underground ventilation	0	0	0	0
	Backfill production and underground placement	0	0	0	0
Milling	Transfer ore to mill	1	0	1	1
	Crushing and grinding	2	0	2	2
	Leaching and U recovery	0	0	0	0
	U purification	0	0	0	0
	Yellowcake drying and packaging	0	0	0	0
	Tailings neutralization	0	0	0	0
	Reagents preparation and use	0	0	0	0
Tailings Management	Pumping and placement of tailings slurry	0	0	0	0
	Consolidation of tailings	0	0	0	0
	Pumping of Tailings Management Facility supernatant	0	0	0	0
Water Management	Create and maintain water levels	0	0	1	0
	Freshwater withdrawal	0	0	0	0
	Potable water treatment	0	0	0	0
	Collection of site and stockpile drainage	0	0	0	0
	Water and sewage treatment	0	0	1	0

Table 11.5-1 Project-Environment Interactions: Terrestrial Wildlife (cont'd)

	Project Activities	Terrestrial Wildlife and Habitat	Raptors and Habitat	Migratory Birds and Habitat	Species at Risk
Operation (cont'd)					
Waste Management	Disposal of industrial waste	0	0	0	0
	Management of hazardous waste	0	0	0	0
	Management of radiologically contaminated waste	0	0	0	0
	Disposal of domestic waste	1	0	0	0
	Discharge of treated effluents (including grey water)	0	0	0	0
	Incineration and handling of burnables	1	0	0	0
	Disposal of sewage sludge	0	0	0	0
General Services	Generation of power	1	0	1	1
	Operate accommodations complex	0	0	0	0
	Recreational activities	0	0	0	0
	Maintain vehicles and equipment	0	0	0	0
	Maintain infrastructure	0	0	0	0
	Operate airstrip	0	0	0	0
	Hazardous materials storage and handling (reagents, fuel and hydrocarbons)	0	0	0	0
	Explosives storage and handling	0	0	0	0
Transportation	Marine transportation	0	0	0	0
	Truck transportation	2	1	1	1
	General traffic (Project-related)	1	1	1	1
	Controlled public traffic	2	1	1	0
	Air transportation of personnel, goods and supplies	2	1	1	1
	Air transportation of yellowcake	0	0	0	0
	General air transportation support	0	0	0	0
Ongoing Exploration	Aerial surveys	2	2	1	1
	Ground surveys	2	1	1	1
	Drilling	1	0	1	0

Table 11.5-1 Project-Environment Interactions: Terrestrial Wildlife (cont'd)

	Project Activities	Terrestrial Wildlife and Habitat	Raptors and Habitat	Migratory Birds and Habitat	Species at Risk
Final Closure					
Economic Activities	Decommissioning Workforce management; Employment; Contracts and taxes	0	0	0	0
General	Hazardous materials storage	0	0	0	0
	Industrial machinery operation	1	0	1	1
	Ongoing withdrawal, treatment and release of water, including domestic wastewater	0	0	1	0
In-water Decommissioning	Remove freshwater diversions; re-establish natural drainage	0	0	0	0
	Remove surface drainage containment	0	0	0	0
	Remove in-water/shoreline structures	0	0	2	0
	Water transfers and discharge	0	0	0	0
	Construct fish habitat as per FHCP	0	0	0	0
On-land Decommissioning	Remove site pads (blasting, earth moving, loading, hauling, dumping)	1	0	1	1
	Backfilling	0	0	0	0
	Contouring	0	0	0	0
	Covering	0	0	0	0
	Revegetation	2	0	2	2
	Remove foundations	0	0	0	0
	Remove buildings	0	0	0	0
	Remove equipment	0	0	0	0
	Remove fuel tanks	0	0	0	0
Post Closure					
	Management of restored site	0	0	0	0

11.6 VALUED ENVIRONMENTAL COMPONENTS, INDICATORS AND MEASURABLE PARAMETERS

11.6.1 Valued Environmental Components

VECs are used to focus the assessment on components of the biophysical environment that if negatively affected by the Project would be a concern to stakeholders. In addition to the scoping obtained from AREVA public meetings and consultation with regulators, the NIRB guidelines identified four terrestrial wildlife and bird VECs in the Project's EIS guidelines (NIRB 2010, Sec. 7.2.1) that are representative of primary species groups and their habitats. The wildlife VECs selected include:

- terrestrial wildlife and their habitat
- raptors and their habitat
- migratory birds and their habitat
- species at risk and their habitat
- seabirds and habitat (addressed in Tier 2, Volume 7 – Marine Environment)

11.6.2 Indicators

Indicators are often used to represent key aspects of the VEC that should be protected to maintain the continued health of the VEC and to protect its value for use by future generations of Nunavut residents. The NIRB guidelines (Sec. 7.2.1) state that caribou, muskox (*Ovibos moschatus*), wolverine (*Gulo gulo*), grizzly bear and wolf (*Canis lupus*) be considered indicators for assessing Project effects on wildlife. Species at risk indicators include those observed or expected to occur within the Project area, including grizzly bear, wolverine, and short-eared owl (*Asio flammeus*).

Caribou and muskox are key wildlife species in the Kivalliq region; therefore, they are the primary indicators of Project effects on terrestrial wildlife and habitat. During community meetings and gathering of IQ, caribou were consistently identified as being important to the Inuit. Caribou are a key food source for Baker Lake residents and are harvested for subsistence purposes, with a relatively small amount harvested for sport. Caribou ecology is relatively well understood owing to current long-term research on caribou in the Kivalliq region, and a wealth of IQ from local residents. Muskox were traditionally harvested by Inuit; the range of muskox has only recently returned to the near-historic levels observed in the early 1900s. Muskox harvest is controlled through a quota system as determined by the GN and the NWMB. The GN has a dated population and distribution survey of muskox in the Kivalliq region; however little IQ has been gathered on muskox (discussed in detail in the terrestrial wildlife baseline report and in the assessment).

Wolf numbers and distribution are likely dependent on the seasonal abundance of caribou in the region; therefore, Project effects on wolves can be indirectly assessed through effects on caribou distribution and abundance. Consequently, wolves are not selected as an indicator species.

Migratory birds are represented by the indicator species lapland longspur (*Calcarius lapponicus*) and long-tailed duck (*Clangula hyemalis*). Lapland Longspur is an indicator because of its known abundance in many upland habitats in the study areas. Lapland longspurs are found within the Project footprint and in portions of the RAA. Long-tailed duck is representative of migratory bird use of waterbodies in the study area. This species is commonly observed throughout the study areas foraging in wetlands, and nesting in areas adjacent to wetlands. Both species are readily recognized by local land users, and there is some traditional knowledge of habitats and potential effects of human disturbance.

Peregrine falcon (*Falco peregrinus*) is an indicator for raptors due to common nesting observations throughout the study area, their high nest site fidelity and the pre-existing knowledge of the species. Peregrine falcon is a COSEWIC Special Concern species due to previous population declines in the southern range of the species associated with the pesticide DDT. The species is readily recognized by land users and there is some traditional knowledge of habitats and potential effects.

Species at risk that are either known or suspected to occur in the RAA include wolverine, grizzly bear, short-eared owl and peregrine falcon. For wolverine and grizzly bear, few observations of these species were recorded during baseline surveys, and most issues specific to wolverine and grizzly bear are readily addressed through mitigation (e.g., Project personnel awareness training, camp and facility cleanliness to avoid attracting wolverine to a site, harvest quota limitations). With so few observations of each species, it is difficult to separate Project-related effects on these species from the natural variation in abundance and distribution. The most common adverse effect of human activities on wolverine and grizzly bears is increased mortality. Mitigations aimed at reducing bear and wolverine mortality will reduce the potential to adversely affect wolverines and grizzly bears. Furthermore, mitigation that reduce effects on prey species, such as caribou and muskox, will benefit wolverine and grizzly bear. There were few short-eared owl observations in the RAA, but existing literature provides enough information to determine Project effects on potential nesting habitat.

Based on available information, NIRB guidelines, stakeholder consultation and professional judgement, the following species are indicators to assess Project environmental effects on wildlife and birds:

- caribou
- muskox
- lapland longspur

- long-tailed duck
- peregrine falcon
- short-eared owl
- grizzly bear
- wolverine

11.6.3 Measurable Parameters

Measurable parameters are used to quantify the potential environmental effects on indicator species. Where habitat classification is possible, the area of suitable habitat can be extrapolated across all indicator species. Terrestrial habitat will be quantified for caribou, wetland habitat for long-tailed duck, and cliff-nesting habitat for peregrine falcon (Table 11.6-1). NIRB guidelines request that habitat, migration and behaviour be included in the assessment of caribou. Predicted behavioural responses to disturbances are used to assess the habitat area potentially affected by mine infrastructure and activities. This assessment also considers mortality risk on caribou, which can be quantified by assessing potential increases in herd harvest.

Table 11.6-1 Measurable Parameters for Terrestrial Wildlife

Wildlife and Bird VEC	Indicator	Environmental Effect	Measurable Parameters	Rationale
Terrestrial Wildlife and Habitat	Caribou	Change in habitat availability	Area (km²) of habitat by suitability class	GN-sourced caribou-based ELC is a powerful and available database.
		Change in mortality risk	Human-caused Mortality Risk by herd	Increased human presence and potential harvest effects on overall herd
		Change in movement	use of water crossings and known migration corridors	Migration to and from calving areas is an important part of caribou life
		Change in health	Radionuclide and metal content in tissues and modelling to predict increased from baseline	Dust deposition on vegetation could expose herbivores to increase metals
	Muskox	Change in habitat availability	Area (km²) of habitat by suitability class	Uses GN-sourced ELC product.
		Change in mortality risk	Human-caused Mortality Risk by herd	Increased human presence and potential harvest effects on population

Table 11.6-1 Measurable Parameters for Terrestrial Wildlife (cont'd)

Wildlife and Bird VEC	Indicator	Environmental Effect	Measurable Parameters	Rationale
Terrestrial Wildlife and Habitat (cont'd)	Muskox (cont'd)	Change in health	Radionuclide and metal content in tissues	Dust deposition on vegetation could expose herbivores to increased metals
Raptors and Habitat	Peregrine Falcon*	Change in habitat availability	Area (km²) of potential nest habitat	There may be limited cliff nesting habitat potential in the Regional Assessment Area
		Reduced chick survival	Nest Site Productivity	Sensory disturbance near nest sites may affect nesting success.
		Change in health	Radionuclide and metal content in tissues	Transfer through the food chain
Migratory Birds and Habitat	Lapland Longspur	Change in habitat availability	Area (km²) of habitat by suitability class	Direct and indirect loss of breeding habitat from footprint and sensory disturbance.
		Change in health	Metal content in tissues	Uptake of contaminants resulting from emissions from the Kiggavik site
Migratory Birds and Habitat (cont'd)	Long-tailed Duck	Change in habitat availability	Area (km²) of habitat by suitability class	Direct and indirect loss of breeding habitat from footprint and sensory disturbance.
		Change in health	Radionuclide and metal content in tissues	Emissions from the water treatment plant and subsequent bioaccumulation in the aquatic food chain
Species at Risk	Short-eared Owl	Change in habitat availability	Area (km²) of habitat by suitability class	Direct and indirect loss of breeding habitat from footprint and sensory disturbance.
		Change in health	Radionuclide and metal content in tissues	Transfer through the food chain
	Wolverine	Change in health	Radionuclide and metal content in tissues	Transfer through the food chain
	Grizzly Bear	Change in health	Radionuclide and metal content in tissues	Transfer through the food chain

11.7 ASSESSMENT BOUNDARIES

11.7.1 Local Assessment Area

The LAA is centered on the Kiggavik and Sissons sites with an approximate 5-km buffer around all proposed Project facilities, including a proposed airstrip and site haul roads. Dimensions of the mine LAA are approximately 29 km wide x 20 km wide, for a total area of 450 km^2 (Figure 11.7-1).

The access road LAAs include a 5-km-wide LAA centered on all four of the proposed road alignments currently under consideration, including the all-season access road alignment and two winter access road alignments. The North All-Season Road has a total LAA of 520 km^2. The South Winter Road has a total LAA of 561 km^2. The North Winter Road, which is currently only considered as a partial segment connecting to other alignments, has a total LAA of 297 km^2. Other potential facilities included within some of the road alignments include a dock facility at Baker Lake and potential quarry sites.

11.7.2 Regional Assessment Area

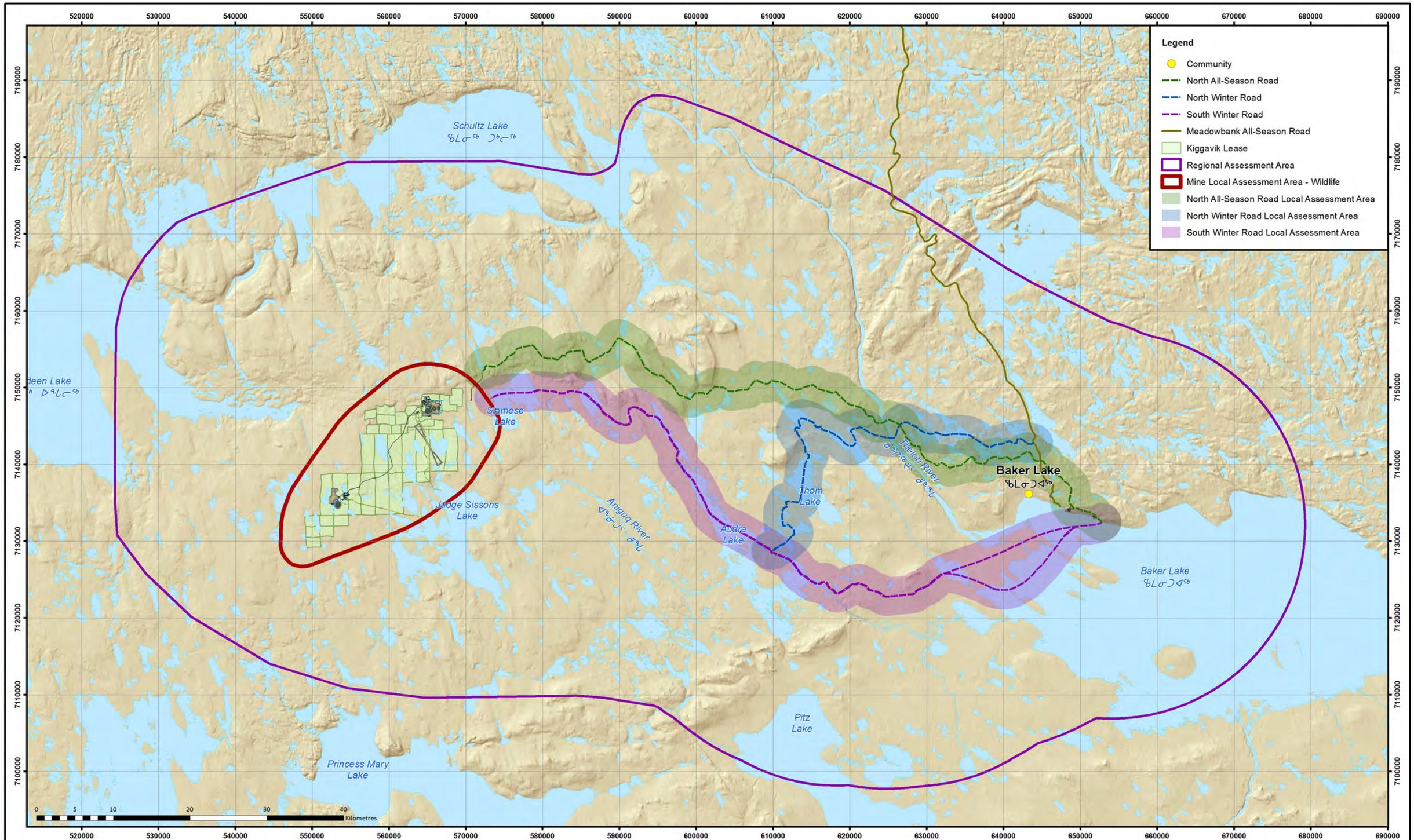
The RAA is a broader area within which cumulative effects may potentially occur, or a VEC is broader ranging. The terrestrial wildlife RAA incorporates all Project features and associated LAA buffers, known caribou water crossing locations along the Thelon River basin (DIAND 1992), and critical areas identified by IQ studies. The RAA also includes areas with similar conditions to those found in the mine LAA and access road LAAs, which will allow the RAA to be used as a comparable reference area for monitoring potential changes as the Project moves forward.

The resulting RAA is 150 km long and 70 km wide, for a total area of 9,828 km^2 (see Figure 11.7-1). The RAA includes all of Judge Sissons Lake and southern portions of Aberdeen and Schultz lakes, whereas Princess Mary Lake is located just to the south.

11.7.3 Administrative and Technical Boundaries

The Project's environmental assessment is subject to administrative and technical limitations. Administrative limitations occur when AREVA has no authority to make adjustments or management decisions because a feature is managed by a government or other organization (e.g., KIA). Technical and/or scientific limitations occur when there is limited or no information on a topic that would inform effect predictions or mitigations. Examples of limitations include:

- Mortality of a wildlife species through harvest may be an important potential cumulative effect, but AREVA does not have authority to manage wildlife harvest.
- Habitat loss across the range of migratory species outside of the Project area cannot be managed or mitigated by AREVA.
- Project effects on species that rarely occur in the region are likely limited, but quantifying effects on rarely occurring species is very difficult because of limited data availability for analysis and low confidence in predictions.
- Long-term Project effects on predatory species due to changes in prey availability are difficult to predict with certainty. Population cycles, prey switching and other predator-prey dynamics become unpredictable over long periods of time, particularly when climate change or other unknowns are also affecting the VEC.



Projection: NAD 1983 UTM Zone 14N
Creator: CDC
Date: 11/18/2011 Scale: 1:450,000
File:
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 11.7-1
LOCATION OF THE WILDLIFE LOCAL AND REGIONAL ASSESSMENT AREAS FOR THE KIGGAVIK PROJECT

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project
AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

11.8 RESIDUAL ENVIRONMENTAL EFFECTS CRITERIA FOR TERRESTRIAL WILDLIFE

Residual effects criteria for wildlife are defined separately by effects within each VEC group. In general, residual environmental effects on the terrestrial wildlife and habitat have been described according to the criteria below.

- ***Direction:*** the trend of the environmental effect (i.e., positive = enhancement of population; neutral = maintains population; or adverse = detrimental effect to population)
- ***Magnitude:*** the degree of change in a variable relative to baseline (i.e., negligible, low, moderate, high). In general, magnitude is quantified for all indicators as either the percent of habitat by suitability class within the RAA, or proportional loss of breeding territories with the RAA. Definitions of magnitude are provided for each VEC in their respective sections.
- ***Geographical Extent:*** the geographic area within which an environmental effect of a defined magnitude occurs (i.e., site-specific, local, regional, territorial, national, international). It is limited to the Project footprint, LAA, RAA, or outside of the RAA.
- ***Frequency:*** the number of times during the Project that an environmental effect may occur (i.e., once, sporadically, regular, continuous)
- ***Duration:*** the period of time that is required until the VEC returns to its baseline condition or the environmental effect can no longer be measured or otherwise perceived (i.e., short term, medium term, long term, permanent). The duration of a potential effect is considered within the combined construction, operation and closure, or beyond closure.
- ***Reversibility:*** the likelihood that a measurable parameter for the VEC will recover from an environmental effect (i.e., reversible = the VEC is able to recover from the effect to a state similar to that existing before the VEC was affected. Depending on the effect considered, reversibility may be assessed on both an individual (immediate) and population (long-term) level; irreversible = the VEC is unable to recover from the effect).
- ***Ecological Context:*** the general characteristics of the area in which the Project is located (i.e., undisturbed, disturbed).

11.9 STANDARDS OR THRESHOLDS FOR DETERMINING SIGNIFICANCE

Standards and thresholds for determining significance are specific to each indicator and are described in the assessment sections.

12 SUMMARY OF EXISTING ENVIRONMENT TERRESTRIAL WILDLIFE AND HABITAT

12.1 CARIBOU

Barren-ground caribou is listed as secure in Nunavut by the Canadian Endangered Species Conservation Council (CESCC 2006).

Caribou that may interact with Project activities includes those from the Beverly, Ahiak, Qamanirjuaq, Lorillard and Wager Bay herds. Recent analyses suggest the presence of a tundra-wintering herd that are referred to here as the “resident” or “Baker Lake” herd, or individuals from the Lorillard and Wager Bay herds.

Based on previous land use studies summarized in the baseline report, most of the Kiggavik RAA was identified as a hunting area in the past. More recent harvest location statistics collected as part of the Nunavut Wildlife Harvest (NWMB 2005) and the ongoing AREVA/AEM Hunter Harvest Study (HHS) indicate that relatively few caribou have been harvested west of the Thelon River in the last decade.

The Beverly herd has recently been documented as substantially declining since population surveys were last conducted in 1994. Although historically the Kiggavik RAA was identified as a post-calving area for Beverly caribou, current use during the post-calving season appears to be limited. The Qamanirjuaq herd has not traditionally been identified as using the Kiggavik RAA during any season; however, observations in 2009 and 2010 and collaring data found that most caribou occurring within the Kiggavik RAA during late July and early August were from the Qamanirjuaq herd. As well, collaring data on the northeast mainland herds (Wager Bay, Lorillard and ‘resident’ herds) has supported the view that most caribou occurring in the Kiggavik RAA in the winter are individuals from these ‘resident’ herds.

As reported through IQ studies and in the literature, recent population declines in several caribou herds may be part of a downward trend in a population cycle that can last from 20 to 60 years.

All caribou herds near the Kiggavik RAA show variation in movements and habitat use among years. Information from IQ studies supports the view that caribou change their migration patterns every few years. Generally, ‘resident’ animals are present during the winter months but summer and calve north and east of the RAA. During the spring migration, individuals of the Beverly/Ahiak and resident herds may be present, but herd numbers are generally low. In

summer, very few caribou are present within the RAA and calving has not been documented. During the post-calving period and summer dispersal period, moderate numbers of Qamanirjuaq and possibly Beverly/Ahiak animals move through the area on their way to wintering areas. Later in the fall, caribou from the 'resident' herds return to the Kiggavik RAA.

In recent years, the entire Kiggavik RAA, but particularly southern portions, seems to be used for migrating mixed age and sex groups of Qamanirjuaq caribou (and possibly some Beverly/Ahiak and resident animals) during the post-calving period. In winter, the northern portions of the Kiggavik RAA seem to be used by wintering 'resident' animals.

Although the annual life cycle of barren-ground caribou has been described according to six seasons, for the purposes of this assessment, habitat use during spring and summer (i.e., growing season) and fall and winter (i.e., winter season) is described. Caribou are most sensitive to disturbances that alter their use of habitat during the late-winter, calving and post-calving periods. Winter, particularly late-winter, is the time of the year when populations of caribou are most limited by habitat and may be subject to forage availability with factors such as snow condition and lichen availability affecting habitat selection. Lichen is the most important source of winter food for caribou because it is relatively high in energy and highly digestible compared to other sources of food. Late-winter is even more critical for cows because they are using more energy during the late stages of gestation. During the spring, energy requirements of female caribou increase because of late-gestation and the start of lactation; therefore, they are more sensitive to disturbances during this period compared to other times of the year.

Caribou need extensive space to undertake traditional movements, presumably, as a strategy to minimize predation, exploit seasonal habitats and avoid deep snow. The RAA has been divided into ELC units that are recognizably different in vegetation content and geographic features. Caribou generally feed on lichen during winters, and fresh shrubs (leaves and stems) and graminoids during the growing season; therefore, habitat that contains these features is of higher value to caribou in the appropriate season.

During the growing season, there is a roughly equal amount of High, Moderate and Low quality habitat distributed throughout the RAA. Most of the High quality habitat in the growing season is situated in southern portions of the Kiggavik RAA, corresponding with the distribution of post-calving aggregations of caribou in 2009 and 2010. In winter, the distribution of most moderate quality habitat corresponds with the distribution of collared caribou in the northwestern portion of the Kiggavik RAA in the winters of 2009 and 2010.

12.2 MUSKOX

Muskox is listed as 'Secure' in Nunavut (CESCC 2006) and is not listed federally under the SARA or by COSEWIC. In the mid-1900s, with concerns about declining populations, the territorial government banned all muskox harvest. Only in recent years has hunting again been permitted on a license basis. To this day, elders and hunters in Baker Lake talk about these restrictions and how the restrictions affected their current hunting patterns. Recently, muskoxen have begun to re-establish populations in many parts of Nunavut. Inuit have suggested that the animals may have moved into the area from the Thelon Wildlife Sanctuary.

Muskoxen were regularly observed during most wildlife survey programs, including the aerial surveys flown in 2007 and 2008. Although muskoxen were found throughout the RAA, the highest number of sightings was in the southeastern portion of the study area just west of the Kazan River, which is consistent with comments by Baker Lake residents. The largest cow-calf group reported numbered 80 individuals, of which a third were likely calves. Overall ratio of calves to cows appears to be in the 30% to 50% range. Most bulls observed were single or in small groups. Muskoxen feed on willow and sedges in the summer and primarily willow, birch and other shrubs in the winter.

12.3 RAPTORS

Eight raptor species were observed in the Kiggavik RAA to date: peregrine falcon, gyrfalcon, rough-legged hawk, northern harrier, bald eagle, golden eagle, short-eared owl and snowy owl. The tundrius subspecies of peregrine falcon, the subspecies that breeds north of the tree line, is listed as 'Secure' in Nunavut (CESCC 2006), Special Concern by COSEWIC, and is on Schedule 3 of the SARA. Short-eared Owl is considered to be 'Sensitive' in Nunavut (CESCC 2006), Special Concern by COSEWIC, and is also on Schedule 3. The only other raptor species considered to be 'Sensitive' in Nunavut is the golden eagle, which is not listed by either COSEWIC or the SARA. The only raptor species documented in IQ studies were eagles.

Peregrine falcons and rough-legged hawks were the most common raptor species encountered during field programs. Nesting birds were closely associated with steep terrain including cliffs and rock outcrops. Most suitable peregrine falcon habitats within the Mine and North All-Season Road LAA were occupied by nesting birds suggesting that cliff-nesting habitat in the Kiggavik area may be saturated with nesting pairs. Sightings of bald eagle and northern harrier in the Kiggavik RAA are unexpected and may be part of a current range expansion.

Peregrine falcon was used as the indicator species for the raptor group because it is the most abundant breeding raptor in the area and it is a federally listed species. Suitable nesting habitat is primarily steep rocky areas and cliffs although nesting has been reported on large rocks. Foraging habitat is determined by the density of available prey, which are primarily birds. The most common prey items are passerines (i.e., snow bunting, lapland longspurs, horned lark, and American pipit), but lemmings, shorebirds, and sik sik are also taken.

12.4 MIGRATORY BIRDS

Fifty-six bird species were observed at the Kiggavik site since 1979. Birds use all habitats within the study area from wetlands (i.e., waterbirds) to upland heath communities (i.e., upland breeding birds).

Waterbirds – Of the 56 bird species observed at the Kiggavik site since 1979, 41 species are waterbirds (i.e., ducks, geese, shorebirds, gulls, terns, jaegers and cranes). Of these, American golden-plover, king eider, ruddy turnstone, semipalmated sandpiper, and Wilson's snipe are considered to be 'Sensitive' in Nunavut (CESCC 2006). No waterbird species observed to date is listed federally in the SARA or by COSEWIC and no other listed species are expected to occur. Some waterbirds and eggs are harvested by local communities, particularly geese (Canada goose, snow goose) and some ducks. Elders and hunters interviewed for IQ studies confirmed that geese were a food source historically, and are still used today.

Population and distribution data on waterbirds were collected from a number of field surveys. The most common and widespread breeding species were Canada goose, sandhill crane, long-tailed duck, semipalmated sandpiper, American golden-plover and herring gull. Snow goose, a migratory species, was seen very commonly in late August and September in some years. Long-tailed Duck was used as the indicator species for the waterbird group because they are one of the most common waterbird species in the area during the growing season, and most wetland habitats are occupied. Long-tailed ducks select nesting sites that are relatively close to waterbodies, with nests frequently located on islands or within 100 m of shorelines. Long-tailed Ducks forage almost exclusively on or at the edge of waterbodies where they consume primarily aquatic insects, crustaceans, fish roe and vegetation.

Upland Breeding Birds – Of the 56 bird species observed at the Kiggavik site since 1979, 15 species are upland breeding birds (includes passerines and ptarmigan). Of these, American tree sparrow, snow bunting, and white-crowned sparrow are 'Sensitive' in Nunavut (CESCC 2006). No upland bird species observed to date is listed federally in the SARA or by COSEWIC and no other listed species are expected to occur. In IQ studies (historical and current), the only upland bird that was reported to be regularly harvested was ptarmigan, which was also one of the most frequently observed upland birds in most baseline field surveys.

Population and distribution data on upland breeding birds were collected from a number of field surveys. The most common and widespread species was Lapland Longspur, which was found in all terrestrial habitat types. Four other common species or species groups, in descending order of abundance, were savannah sparrow, redpoll, ptarmigan and horned lark. Given the abundance of Lapland Longspurs in the study area and the diversity of habitats used, they were selected as the indicator species for upland breeding birds in this assessment. Foraging habitats for longspurs are most often wet tundra meadows that are relatively flat; however, they will also use drier vegetated slopes. Nesting habitat is usually well-vegetated meadows.

12.5 SPECIES AT RISK

The only species at risk recorded within the Kiggavik study area to date include peregrine falcon, short-eared owl, wolverine and grizzly bear. A brief summary of abundance and distribution of the latter three species is provided below.

Short-eared Owl – The short-eared owl is listed as Special Concern by COSEWIC and is on Schedule 3 of the SARA. Short-eared owls were rarely observed during the field surveys, but nesting was suspected. Graminoid, Shrub and Heath Tundra habitats, which are widespread and readily available within the RAA, provide good nesting habitat for Short-eared Owls. Key prey items for Short-eared Owls are small mammals including lemmings and red-backed vole.

Wolverine – Wolverine is listed as 'Secure' in Nunavut (CESCC 2006) and as a species of Special Concern by COSEWIC, but is not listed under the SARA. The presence of wolverine in the Kiggavik RAA was confirmed during IQ studies, although low populations were noted. Some Elders commented that wolverine is one of the few targeted species that is not often found close to Baker Lake. Wolverine is an important furbearing species for residents of Baker Lake, and the maintenance of a healthy population is important for local trappers.

Very little demographic information is available for wolverine largely because of their solitary nature and dispersion across the landscape. Wolverines were only occasionally recorded during field surveys in the Kiggavik RAA and appeared to be distributed across the entire Kiggavik RAA. No particular area, other than possible den sites, appears to be of critical importance.

Grizzly Bear – Grizzly bear is listed as 'Sensitive' in Nunavut (CESCC 2006) and is federally listed as Special Concern by COSEWIC, but is not listed under the SARA. The presence of grizzly bear in the Kiggavik RAA was confirmed during IQ studies, although comments noted that populations were low. According to Baker Lake community members, numbers of grizzly bears, and the number being killed each year, have been increasing steadily over the last few years. Previous IQ studies have also indicated that the number of harvested grizzly bears in the area has increased. The increase in grizzly bear populations and an apparent eastward range expansion has also been documented in the literature.

Minimal demographic information is available for grizzly bear, largely because they are solitary and very widely dispersed on the landscape. Grizzly bear were only occasionally recorded during field surveys in the Kiggavik RAA and appeared to be distributed across the entire RAA. No particular area, other than possible den sites, appears to be of critical importance. During IQ studies, interviewees noted that grizzly bears have been observed in the area of Qikiqqtarjualik (Judge Sissons) Lake, near Shultz Lake and north of Baker Lake.

13 EFFECTS ASSESSMENT FOR CARIBOU AND MUSKOX

13.1 SCOPE OF THE ASSESSMENT FOR CARIBOU AND MUSKOX

The terrestrial wildlife effects assessment focuses on the indicator species caribou and muskox.

13.1.1 Project-Environment Interactions and Effects

Project activities have the potential to affect the abundance and distribution of caribou and muskox within the Kiggavik RAA. Key issues related to effects on caribou and muskox are:

- direct effects associated with a potential increase in mortality from wildlife-vehicle collisions
- reduced habitat availability from the Project footprint that results in a direct loss of foraging habitat
- sensory disturbances that result in an indirect loss of functional habitat
- change in seasonal movements caused by physical structures (e.g., road embankment, open pits, buildings) and sensory disturbances (only caribou are assessed for effects on movements, as muskox do not exhibit seasonal migrations from wintering grounds to birthing grounds)
- change in population health

Key Project components that could affect caribou and muskox are outlined in Table 13.1-1.

13.1.2 Residual Environmental Effects Criteria for Caribou and Muskox

Residual effects on caribou and muskox were characterized quantitatively and qualitatively using the following six attributes: direction, magnitude, geographic extent, frequency, duration and reversibility. Table 13.1-2 provides definitions for these attributes.

Table 13.1-1 Project-Environment Interactions and Effects on Caribou and Muskox

Project Component	Project Activities	Environmental Effect			
		Change in Mortality	Change in Habitat	Change in Movement	Change in Health
Construction					
On-Land Construction	Site clearing and pad construction (blasting, earth moving, loading, hauling, dumping, crushing)		✓	✓	
Supporting Activities	Transport fuel and construction materials	✓		✓	
	Air transport of personnel and supplies		✓	✓	
	Explosives storage and use		✓	✓	
Operation					
Mining	Mining ore (blasting, loading, hauling)		✓	✓	✓
	Mining clean waste (blasting, loading, hauling)		✓		✓
Milling	Crushing and grinding		✓		✓
Transportation	Truck transportation	✓		✓	
	General traffic (Project-related)	✓	✓	✓	
	Controlled public traffic	✓		✓	
	Air transportation of personnel, goods and supplies		✓	✓	
Ongoing exploration	Aerial surveys			✓	
	Ground surveys			✓	
Final Closure					
On-land Decommissioning	Revegetation		✓		

NOTES:

Only Project interactions ranked as 2 in Table 11.5-1 are carried forward to this table.

A ✓ indicates that an activity is likely to contribute to the effect.

Table 13.1-2 Residual Environmental Effects Criteria for Caribou and Muskox

Attribute	Description	Rating	Definition
Direction	The ultimate long-term trend of the environmental effect	Positive	Reduced mortality risk, reduced barriers to movement, increased habitat availability, or improvements in animal health relative to baseline conditions
		Neutral	No change in mortality risk, habitat, movement or animal health
		Adverse	Increased mortality risk, increased barrier to movement, decreased habitat availability, or decrease in animal health relative to baseline conditions
Magnitude	Amount of change in a measurable parameter relative to baseline conditions	Negligible	No measurable change, or no anticipated effect on species
		Low	Observable effect on wildlife species but not likely to affect species' sustainability in the LAA
		Moderate	Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the RAA
		High	Measurable effect on wildlife species that will likely affect the species' sustainability in the RAA
Geographic Extent	The geographic area within which an environmental effect occurs	Local	Effect confined to the LAA
		Regional	Effect extends beyond the LAA but within the RAA
		Territorial	Effect extends beyond the RAA but within Nunavut
		National	Effect extends beyond Nunavut but within Canada
Frequency	Number of times that an effect may occur over the life of the Project	Once	Effect occurs once throughout the Project
		Sporadically	Effect occurs occasionally but not consistently throughout the life of the Project
		Regularly	Effect occurs repeatedly at regular intervals throughout the life of the Project
		Continuous	Effect occurs continuously throughout the Project
Duration	Length of time over which the effect is measurable	Short term	Less than one year
		Medium term	More than one year, but not beyond the end of the Project.
		Long term	Beyond the life of the Project
Reversibility	Likelihood that a measurable parameter for a VEC will recover from an environmental effect to baseline conditions	Reversible	Will likely recover to baseline conditions after or before the end of the Project.
		Irreversible	Unlikely to recover to baseline conditions after the end of the Project.

13.1.3 Standards or Thresholds for Determining Significance

No standards or thresholds exist for determining the significance of Project effects on caribou and muskox. The Project is not located within any known caribou calving grounds and there are no protected water crossing areas located within 10 km of the Project. In the absence of legislated or otherwise identified thresholds, the significance of effects are determined based on professional judgment. Determination of whether the Project's residual effects on caribou and muskox are considered significant is based on whether the effect influences the long-term viability of a population or delays its recovery. A residual effect is considered not significant if the effect causes a change in the condition of an individual or population (or their habitat) that is within the range of natural variability or does not affect the integrity of a population in a measurable way.

Mortality – Increased mortality risk is considered to be a significant effect if caribou or muskox herd-specific mortality is increased beyond a level of sustainable harvest (e.g., TAH, or greater than 5% mortality for overall harvest of the "standing stock" of a given caribou herd (a sustainable harvest level for caribou identified by the Kivalliq Regional Biologist; Campbell et al. 2010). Standing stock is 75% of a total herd estimate. The same TAH is assumed for muskox herds.

Habitat – Based on professional opinion from experience on other northern projects, and knowledge of caribou and muskox ecology, Project effects on habitat availability are considered significant if more than 5% of caribou growing or winter range becomes unsuitable for use by caribou; or, if the muskox wildlife management unit MX/21 becomes unsuitable for use by muskox.

Movement – Based on professional opinion, Project effects on movement are considered significant if more than 10% of the animals in a herd are diverted by Project activities such that the animals do not arrive at calving grounds or wintering areas.

Health – For this assessment, the estimated exposure to COPC by wildlife and birds is compared to values that are set to be protective of health and if the exposure is lower than this value then no adverse effects are expected. The estimated dose received by the biota from exposure to radioactivity, considering both baseline and Project emissions, is compared to a level that is protective of mammals.

Potential changes in a measurable parameter or VEC resulting from Project or cumulative effects were evaluated against these standards or thresholds, and were rated as either significant or not significant.

13.2 EFFECTS ASSESSMENT FOR CARIBOU AND MUSKOX

13.2.1 Assessment of Change in Mortality

Caribou and muskox mortality can be affected by human developments through direct mortality from collisions with vehicles, and indirect mortality from changes to activity budgets potentially increasing individual energetic demands leading to reduced survival (Bradshaw et. al. 1998). Direct mortality from collisions with vehicles are quantifiable. Changes to activity budgets and resulting effects on energy balance are currently addressed using a measure of reduced habitat effectiveness described below. The effect of potential increased harvest is addressed as a cumulative effect in Section 13.3.2.

13.2.1.1 Analytical Methods for Change in Mortality

The potential for vehicle-wildlife collisions occurring because of the Project was based on experience at other northern mine sites that encounter caribou. Vehicle-caribou collisions are unlikely to occur due to the low densities of caribou with the RAA during the winter. In addition, reduced speed limits (30 km/hr) on a winter road reduces the potential occurrence for vehicle-caribou collisions.

13.2.1.2 Baseline Conditions for Change in Mortality

Rates of natural mortality factors are unknown for the herds of interest (the current state of knowledge summarized in Campbell et al. 2010). Road collisions are known to occur on the Meadowbank Road: two or three are known to have occurred since 2008 (M. Gebauer, pers. comm.). To determine the Project's potential for increased risk of caribou mortality, an understanding of the seasonal distribution of caribou herds that can be found within the RAA is necessary (see the baseline report, Tier 3, Appendix 6C). Only summary information is provided in this section.

13.2.1.2.1 SEASONAL CARIBOU DISTRIBUTION IN THE RAA

Seasonal caribou presence in the RAA and adjacent areas is presented in Table 13.2-1. This information is suitable for determination of potential effects of vehicle-caribou collisions. A detailed description of caribou distribution and population trends is presented in the cumulative effects section where the potential cumulative effect of increased harvest is discussed.

Table 13.2-1 Caribou Seasonal Observations within the Kiggavik RAA

Activity	Estimated dates	Satellite Collar Locations and Observed Caribou within the RAA
Spring migration	March 16 – May 25	Qamanirjuaq — Caribou from the Qamanirjuaq herd have been documented within the southeastern portion of the RAA during this pre-calving season (GN unpublished data). Resident – Caribou from the Resident herd are regularly present within the RAA during this period.
Calving	May 26 – June 25	No collared animals observed during calving in the RAA. No historical evidence of caribou calving in the RAA.
Post-calving aggregation	June 26 – July 31	The Kiggavik RAA is located near the edge of post-calving areas for the Beverly herd (to the north) and the Qamanirjuaq herd (to the south). The RAA has traditionally been included within a broader post-calving area for the Beverly (not Qamanirjuaq). Qamanirjuaq — Satellite collar data show that 2009 was the first year that collared Qamanirjuaq animals have moved through the RAA during the post-calving period. Large numbers observed in 2009 and 2010 were most likely from this herd. Other – Several hundred animals (including cows and calves) were observed crossing the Thelon River from north to south in July 2010. Animals could have been from the Beverly/Ahiak, Resident or Qamanirjuaq herds.
Summer dispersal	August 1 – September 15	Caribou numbers increase in the RAA beginning at the end of the post-calving period and into the summer dispersal period. Based on recent collaring data, these caribou appear be primarily from the Qamanirjuaq herd. It is possible that some individuals were from the Resident and Beverly/Ahiak herds.
Rut and fall migration	September 16 – October 31	Beverly/Ahiak — At least one collared animal observed north of the RAA Qamanirjuaq — At least one collared animal observed south of the RAA
Early and Late winter	November 1 – March 15	Some collared animals (regardless of designated herd) that remain on the tundra have been found in the RAA.

13.2.1.2.2 OTHER SOURCES OF MORTALITY

Starvation, predators, and disease are mortality factors for caribou. There is no available information on trends or proportions of mortality from natural causes. An overview of current knowledge of these factors in provided in Campbell et al. (2010). However, there were no issues identified in that review that are known to interact with Project activities. For the purposes of this assessment, mortality due to these natural causes are presumed to be constant, not influenced by the Project, and are not discussed further.

13.2.1.3 Effect Mechanisms and Linkages for Change in Mortality

Project-related activities could directly cause mortality events through vehicle collisions, resulting in reduced wildlife abundance within the RAA.

To date, the potential effects of resource road access in Nunavut has not been documented as a wildlife management issue for the GN. In their TAH report (Government of Nunavut 2005), the GN suggests that further strategic study is required to address information gaps on caribou populations. The report suggests:

- population monitoring using scientific air or ground surveys or telemetry devices attached to caribou
- surveys of parasite loads and effects of parasitism and disease on caribou population dynamics
- comprehensive mapping of habitat to monitor effects of habitat change over time on caribou population dynamics
- improved understanding of predator-prey dynamics
- further documentation of Inuit knowledge

The GN's Draft Caribou Strategy Framework (Government of Nunavut 2010) identifies a growing need to address the effects of human use of the landscape on caribou populations.

13.2.1.4 Mitigation Measures and Project Design for Change in Mortality

Mitigation for vehicle-caribou collision mortality is the responsibility of AREVA and the following can measures can be implemented to reduce mortality:

- temporary road shut downs to accommodate seasonal wildlife movements near the road
- reduced speed limits to avoid collisions with wildlife

13.2.1.5 Residual Effects for Change in Mortality

The Project could result in adverse effects on caribou through a direct increase to caribou mortality risk. Direct mortality could result from caribou-vehicle collisions.

13.2.1.5.1 Mine and North All-Season Road

Caribou-vehicle collisions may occur, but the identified mitigation will make these events unlikely. The magnitude of the effects regarding the interaction of the Project with the caribou herds is expected to be low. The frequency of increased mortality risk is continuous and will occur throughout the duration of the Project; however, the effects are expected to be local. The residual effects will be reversible following decommissioning of the road during the final closure phase.

13.2.1.5.2 Mine and Winter Roads

Project mitigation will greatly reduce the potential for caribou-vehicle collisions, and effects at the caribou population level will be undetectable. The magnitude of potential Project effects on caribou mortality risk is expected to be negligible.

13.2.1.6 Determination of Significance for Change in Mortality

There is a very low potential for direct mortality risk from collisions with caribou along the access roads. The winter roads have much reduced speed limits, so collisions will be very unlikely as vehicles should be able to stop quickly if caribou are on the road. The North All-Season Road has faster speed limits, but vehicles should still be able to avoid collisions with caribou, particularly with communication among vehicles travelling the road. Despite mitigation measures, the likelihood is high that caribou will occasionally collide with mine vehicles, but the overall number of affected individuals will be small.

The magnitude of Project effects on caribou mortality risk is predicted to be negligible. Any effect will be undetectable at the local scale, will occur continuously during mine operation, and is reversible following final closure of the Project. Confidence is high in this prediction because there have only been two or three incidents of vehicle-caribou collisions since 2008 (i.e., less than one collision per year of operation) on the Meadowbank Road, which is relatively close to Project roads.

13.2.1.7 Summary of Project Residual Environmental Effects for Change in Mortality

Project effects on increased mortality risk of Qamanirjuaq and Resident caribou is expected to be not significant since the Project is not expected to contribute to caribou mortality such that numbers are detected at the population level. Table 13.2-2 summarizes the residual environmental effects of the Project for change in mortality to caribou. Both winter road options reduce the potential for an increase in mortality risk for caribou. The North All-Season Road option would slightly increase potential for an increase in caribou mortality risk, but AREVA's management actions are expected to mitigate the potential for Project related mortality. However, all road options are expected to have no significant effects on caribou herds that interact with the Project.

Table 13.2-2 Summary of Residual Environmental Effects for Change in Mortality to Caribou

Project Phase	Mitigation / Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in Caribou Mortality Risk — North All-Season Road Option												
Construction		N	N	L	MT	C	R	U	N	N/A	H	None recommended
Operation	Road closures. Private access. Multi-party management speed limits, use of convoys	N	N	L	MT	C	R	U	N	N/A	M	Road check-point monitoring, HHS
Final Closure	Road closures; private access; multi-party management	N	N	L	MT	C	R	U	N	N/A	M	Road check-point monitoring, HHS
Change in Caribou Mortality Risk— South and North Winter Road Options												
All Project Phases		N	N	L	MT	C	R	U	N	N/A	M	Continued monitoring (collar studies) of migratory and Baker Lake herd distribution during winter road operation, HHS

Table 13.2-2 Summary of Project Residual Environmental Effects for Change in Mortality to Caribou (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible: No anticipated effect on wildlife species

L Low: Observable effect on wildlife species but not likely to affect the species' sustainability in the Project area

M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the region

H High: Measurable effect on wildlife species but that will likely affect the species' sustainability in the region

Geographic Extent:

S Site-specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

13.2.1.8 Compliance and Environmental Monitoring for Change in Mortality

Compliance and environmental monitoring for changes in mortality to caribou and muskox includes the following:

- continue participation in the GN-led caribou collaring program (determine seasonal distribution by herd)
- support GN-led herd delimitation and population estimate survey (determine regional herd population trends)
- report all wildlife collisions and monitor trends seasonally and annually
- continue Project-specific caribou monitoring programs (e.g., ground-based observations)

13.2.2 Assessment of Change in Habitat Availability

The Kiggavik Project will result in a loss of caribou and muskox habitat. Habitat availability can be affected by human developments through two pathways:

1. direct habitat loss due to Project construction (i.e., the Project footprint) will reduce the amount of habitat available
2. indirect habitat loss from human activity associated with the Project that causes a functional loss of habitat (avoidance due to sensory disturbances such as that associated with noise and dust)

13.2.2.1 Analytical Methods for Change in Habitat Availability

The assessment of changes in habitat availability for caribou focussed on the resident (non-migratory) Baker Lake and the Qamanirjuaq herds because these herds were identified to use the RAA the most during the winter and growing seasons, respectively. The remaining herds use the RAA less frequently; therefore, Project-related effects will likely be less for these herds.

The Qamanirjuaq and Baker Lake herd seasonal range size was calculated using the minimum convex polygon technique from the collar data. The winter season is defined as 1 October to 31 May, and the growing season is defined as 1 June to 30 September. The polygon was generated after removing outlier locations, as well as Hudson Bay (i.e., it was assumed that Hudson was not used by caribou due to the lack of forage). The resulting predicted range for the Qamanirjuaq herd during the growing season was 479,500 km², whereas the Baker Lake herd's winter season range was predicted to be 385,600 km². Although these range sizes are considered conservative, they roughly represent the potential area used by the Qamanirjuaq and Baker Lake herds during the respective seasons.

Available habitat for caribou and muskox was quantified during baseline studies using ELC units. Habitat quality for the ELC units for caribou and muskox was rated as high, moderate or low based on the vegetation composition for the ELC units and the ungulate's habitat requirements during the growing and winter seasons. Ratings were determined during baseline studies.

Direct loss of caribou and muskox habitat was assessed by identifying ELC units that will become unavailable because of the footprint of the mine site and road options. The winter road options will remove habitat in winter, but the habitat will be available again each summer when the road is decommissioned.

Indirect loss of habitat was assessed by reducing habitat quality (ELC unit quality) for growing and winter seasons within the mine site and access road options. Based on predicted caribou response to disturbances, habitat quality within the mine site Zone of Influence (ZOI) was reduced by two classes to a minimum of low within 7 km of the mine footprint, and by one class to a minimum of low within 14 km of the mine footprint. Habitat quality within each access road option ZOI was reduced by two classes to a minimum of low within 1 km of the access road footprints, and by one class to a minimum of low within 4 km of the access road footprints. The winter access road ZOI was only applied to the winter season assessment because the road will not be present during the growing season and, consequently, disturbance along the road will also be absent during this period.

A habitat unit index was developed to assess the overall loss of caribou and muskox habitat availability within the RAA. The index is based on assigning a ranked value to each habitat class (e.g., high=3, moderate=2, low=1, nil=0), and summing the available habitat, measured in hectares, weighted by the value of each class. The difference in the weighted sum of available habitat for the baseline conditions, and the predicted direct and indirect loss of habitat indicate the expected change in caribou and muskox habitat.

13.2.2.2 Baseline Conditions for Change in Habitat Availability

13.2.2.2.1 Caribou

Caribou habitat quality within the RAA is described in the wildlife baseline report (Tier 3, Appendix 6C) and linked to ELC units. Caribou feed on lichen during the winter period and fresh shrubs (leaves and stems) and graminoids during the growing season (Adamczewski et al. 1988). A description of the ELC units and their value to caribou is presented in Table 13.2-3. During the growing season, the RAA contains mostly high, moderate and nil quality habitats (Table 13.2-4). Habitat rated as nil during the growing season is due to the abundance of water in the RAA. During the winter season, there is a roughly equal amount of high, moderate and low quality habitat distributed throughout the RAA (Table 13.2-4). Most of the high quality habitat during the growing season is located in the southern portions of the Kiggavik RAA.

Table 13.2-3 Description and Relative Value of ELC Units for Caribou during the Growing and Winter Seasons in the RAA

ELC Unit	Growing	Winter	Reasoning
Water	N	L	Water is not important caribou habitat, but can be used during the winter (ice). Shorelines may provide some insect relief, but other habitats associated with elevation provide better relief
Sand	M	L	Caribou select habitats containing predominately sand during the growing season to avoid insect harassment (BQCMB 1999). The value of sand in winter is low because the habitat contains limited food and there are no insects in winter
Gravel	M	L	Caribou select habitats containing predominately gravel during the growing season to avoid insect harassment (BQCMB 1999). The value of gravel in winter is low because the habitat contains limited food and there are no insects in winter.
Rock Association	L	L	Rock association provides little usable habitat for caribou as there is little available food.
Wet Graminoid	H	M	Wet graminoid habitat was categorized as high during the growing season due to new vegetative growth that is high in energy content, easily digestible, and abundant. Caribou select graminoids while foraging during the spring and summer periods; however, caribou avoid areas containing sedges and peat bogs in fall. Nevertheless, the overall rating for the growing season is high.
Graminoid Tundra	H	M	Graminoid tundra was categorized as high during the growing season due to new vegetative growth that is high in energy content, easily digestible, and abundant. In winter, forage quality decreases, therefore, so does habitat value.
Graminoid/ Shrub Tundra	H	M	Graminoid/shrub tundra has a similar value to the graminoid tundra and wet graminoid ELC units because it contains high quality seasonal vegetation, as well as more open shrubs (compared to straight shrub habitat). It may be of higher value than graminoid tundra because of the diversity of food types that are selected by caribou – shrub, lichen and graminoid.
Shrub Tundra	M	L	Shrubs (willows) form a large part of caribou diet during the growing season and there is evidence that caribou select riparian areas during post-calving season, but caribou do not select this habitat type in winter.
Shrub/Heath Tundra	H	M	Shrub/heath tundra habitat is considered important during the growing season because it contains willows as well as other sources of food. The value is lower in winter because caribou focus more on areas where lichen is present.
Heath Tundra	M	H	This habitat type has all the vegetation used by caribou during the growing season. Due to the abundance of lichen, the value is higher in the winter.
Heath Upland	M	H	This habitat type has all the vegetation used by caribou during the growing season. Due to the abundance of lichen the value is higher during the winter. Ridge tops my also provide areas of reduced snow depth.
Lichen Tundra	M	H	Lichen is the most important food source for caribou in winter. During the growing season, when caribou select for other food, lichen is still part of their diet and they still spend time in these areas, but not to the same extent.
Heath Upland/ Rock Complex	L	M	Relatively low value during the growing season because of the rock content, but is higher during the winter because of lichen content.
NOTE: Growing season is defined as approximately June 1 to September 30 (four months). Winter season is defined as approximately October 1 to May 31 (eight months). . H = High; M = Moderate; L = Low; N = Nil			

Table 13.2-4 Availability of Caribou Habitat within the RAA during Growing and Winter Seasons

ELC rating	Growing Season (%)	Winter Season (%)
High	34	29
Moderate	35	39
Low	6	32
Nil	26	0
No Rating	0	0

13.2.2.2.2 Muskox

Muskox habitat quality within the RAA is described in the baseline report and linked to ELC units. Muskox primarily feed on willow and sedges during the summer (Gunn and Sutherland 1997; Nellemann and Reynolds 1997). ELC units with a large willow component are Graminoid/Shrub Tundra, Shrub Tundra and Shrub/Heath Tundra. Earlier in the summer, muskox are known to feed on sedges (Gunn 1984) that are found within the Graminoid/Shrub Tundra, Shrub Tundra and Shrub/Heath Tundra ELC units (Table 13.2-5). Most of the habitat within the RAA is classified as moderate quality, and no high quality habitats for muskox are found within the RAA during the growing season (Table 13.2-6). The majority of the habitat within the RAA is classified as moderate quality for the winter period; however, there is an increase in the amount of habitat considered in both categories of high and low quality (Table 13.2-6).

Table 13.2-5 Description and Relative Value of ELC Units for Muskox during the Growing and Winter Seasons in the RAA

ELC Unit	Growing Season	Winter Season	Reasoning
Water	N	L	Water is not important muskox habitat in either season, but can be travelled across during frozen periods in the winter (ice).
Sand	L	L	Sand is not important muskox habitat in either season as there is little available food.
Gravel	L	L	Gravel is not important muskox habitat in either season as there is little available food.
Rock Association	L	L	Rock association provides little usable habitat for muskox as there is little available food.
Wet Graminoid	M	M	Wet graminoid habitat was categorized as moderate for both the growing and winter seasons because of the availability of preferred foods including grasses, sedges and willows/shrubs.
Graminoid Tundra	M	M	Graminoid tundra habitat was categorized as moderate for both the growing and winter seasons because of the availability of preferred foods including grasses, sedges and willows/shrubs.

Table 13.2-5 Description and Relative Value of ELC Units for Muskox during the Growing and Winter Seasons in the RAA (cont'd)

ELC Unit	Growing Season	Winter Season	Reasoning
Graminoid/ Shrub Tundra	M	M	Graminoid/shrub tundra habitat was categorized as moderate for both the growing and winter seasons because of the availability of preferred foods including grasses, sedges and willows/shrubs.
Shrub Tundra	M	H	Shrubs (willows) form a large part of a muskox's diet for both the growing and winter seasons, but particularly in winter when deep snow limits access to grasses and sedges in low-lying areas.
Shrub/Heath Tundra	M	H	Shrubs (willows) form a large part of a muskox's diet during the growing and winter seasons, but particularly in winter when deep snow limits access to grasses and sedges in low-lying areas.
Heath Tundra	M	M	Heath tundra habitat has shrubs used by muskox for both the growing and winter seasons. Due to the shallower snow depths in these areas, shrubs are more accessible, although they occur at lower densities than in wetter habitats.
Heath Upland	M	M	Heath upland habitat has shrubs used by muskox for both the growing and winter seasons. Due to the shallower snow depths in these areas, shrubs are more accessible, although they occur at lower densities than in wetter habitats.
Lichen Tundra	L	L	Lichen is not an important food source for muskox in any season.
Heath Upland/ Rock Complex	L	L	Due to the high densities of rock, shrub availability is lower than in the heath upland habitat unit.
NOTE: Growing season is defined as approximately June 1 to September 30 (four months). Winter season is defined as approximately October 1 to May 31 (eight months). H = High; M = Moderate; L = Low; N = Nil			

Table 13.2-6 Availability of Muskox Habitat within the RAA during Growing and Winter Seasons

ELC rating	Growing Season (%)	Winter Season (%)
High	0	10
Moderate	66	56
Low	8	34
Nil	26	0
No Rating	0	0

13.2.2.3 Effect Mechanisms and Linkages for Change in Habitat Availability

The Kiggavik Project will reduce habitat availability for caribou and muskox within the RAA. Direct habitat loss from the Project footprint will likely remain unavailable as foraging habitat beyond the life of the Project. Although decommissioning includes revegetation, for the purposes of this assessment, the entire footprint is considered long-term habitat loss. Indirect, or functional, habitat loss is a reduction of habitat effectiveness due to Project activities that cause animals to avoid habitats. Sensory disturbances are the primary cause of animals avoiding areas closer to disturbing stimuli (Stankowich 2008). For caribou, visual stimuli (as opposed to aural stimuli,) cause a greater change in activity, possibly because caribou tend to live in windy and, therefore, noisy environments. Olfactory and taste stimuli have not been studied, but anecdotal information suggests that smell can elicit a flight response in the absence of visual or aural stimuli. Reimers and Colman (2006) reviewed caribou response to human activities and concluded:

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

For caribou, the extent of indirect habitat loss is at the scale of kilometres (Wolfe et al. 2000; Mayor et al. 2009). Caribou response to human disturbance varies by the ecosystems and activities to which they have adapted. Recent studies using caribou collar data have provided insight into an understanding of which habitat features caribou select and how caribou perceive their environment. Woodland caribou have been reported responding to human caused changes in habitat at distances up to 15 km (Mayor et al. 2009).

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

Although the overall caribou responses to human activity along roads in previous studies are negative, caribou may seasonally choose to be near roads. First, caribou may select gravel roads as an important landscape feature during times of high insect abundance because a road tends to be elevated and exposed to greater wind speed, thus reducing insect harassment (Hanson 1981). Second, a 'dust shadow' effect was observed along roads in oilfield development areas of Alaska (Cronin et al. 1994 cited in Klein et al. 2000). Increased dust levels from vehicle traffic may result in earlier snowmelt and vegetative growth in spring, facilitating access to higher quality vegetation prior to parturition; conversely, intense dust deposition can change the vegetation cover and reduce overall availability to forage (Klein et al. 2000), or a change in palatability (taste). Dust from mining activities could be the mechanism that reduces the abundance of caribou within the area around a mine site. At the Ekati mine in the Northwest Territories, monitoring of caribou abundance showed that caribou were four times more likely to be found more than 14 km from mine activities than adjacent to activities (Boulanger et al. 2009). The mechanism of the change in caribou habitat use at Ekati is unclear, but hypothesized to be associated with a combination of dust deposition and other sensory disturbances.

There is very limited information on muskox responses to industrial development and human disturbance. The lack of information is likely because few projects interact with muskox. Because they are a high arctic species, muskox were absent from much of their range during most of the last century. Compared with caribou, muskox have not been a valued species for northern communities because they are not abundant enough to support subsistence harvest. It is assumed that the identified caribou ZOI is representative of the muskox ZOI. Given the body size of muskox and their ability to deter predation, they are likely less sensitive to disturbance than caribou. Consequently, the caribou ZOI applied to muskox is a conservative estimate of potential muskox habitat loss. Comparison of similar studies of muskox and reindeer response to snowmobile disturbance suggests that these animals respond at a similar spatial scale to human disturbance. Studies have found that reindeer and muskox react to approaching snowmobiles when the machines were 534 m (Reimers et al. 2003) and 345 m (McLaren and Green 1985) away.

13.2.2.4 Mitigation Measures and Project Design for Change in Habitat Availability

Mitigation measures that will be implemented to reduce Project effects on habitat availability for caribou and muskox include:

- Maintaining Project activities within the surveyed boundaries of the Project footprints will keep habitat loss within expected bounds.
- Managing road activity during important seasonal migratory seasons and during post-calving will minimize sensory disturbances during sensitive periods of caribou life history.
- Progressively reclaiming disturbed areas will advance timing of habitat recovery.
- Providing dust suppression along roads during dry summer periods will reduce the sensory disturbances associated with dust.
- Eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings will eliminate the sensory disturbances associated with dust from tailings.
- In the case of the winter road options, reducing the Project footprint will mitigate habitat loss and reduce the likelihood of the Project acting cumulatively with habitat loss other projects in the Kivalliq region.

13.2.2.5 Residual Effects for Change in Habitat Availability

Despite the implementation of mitigation measures, caribou and muskox habitat will still be lost due to direct and indirect effects. Direct loss of habitat from the footprint of the Project and associated facilities cannot be mitigated. The following sections summarize the predicted effects for each construction option.

13.2.2.5.1 Mine and North All-Season Road

The mine site and North All-Season Road option cause a direct loss of caribou and muskox habitat during both the growing and winter seasons, resulting in a loss of 1,704 ha of previously usable habitat in the RAA. This corresponds to roughly 0.17% of available habitat in the RAA.

Caribou

Avoidance of habitat within the ZOI results in a reduction in the quality of habitat. During the growing season, the Project is expected to result in a 24% loss of available high quality habitat, 11% loss of available moderate quality habitat and a corresponding 204% increase of low quality habitat within the RAA (Figure 13.2-1). During the winter season, the Project is expected to result in a 27% loss of available high quality habitat, 11% loss of available moderate quality habitat and a corresponding 38% increase of low quality habitat within the RAA (Figure 13.2-2). This equates to an overall loss of 11% of growing season habitat units and 10% of winter season habitat units within the RAA (Table 13.2-7). Comparing this change in available habitat within the RAA to the range of the focal caribou herds, Baker Lake and Qamanirjuaq, the reduced habitat availability corresponds to a reduction of 0.2% of the Qamanirjuaq growing season range and 0.3% of the Baker Lake winter range.

Table 13.2-7 Caribou Habitat Baseline and Predicted Effects for the Mine Site and North All-Season Road

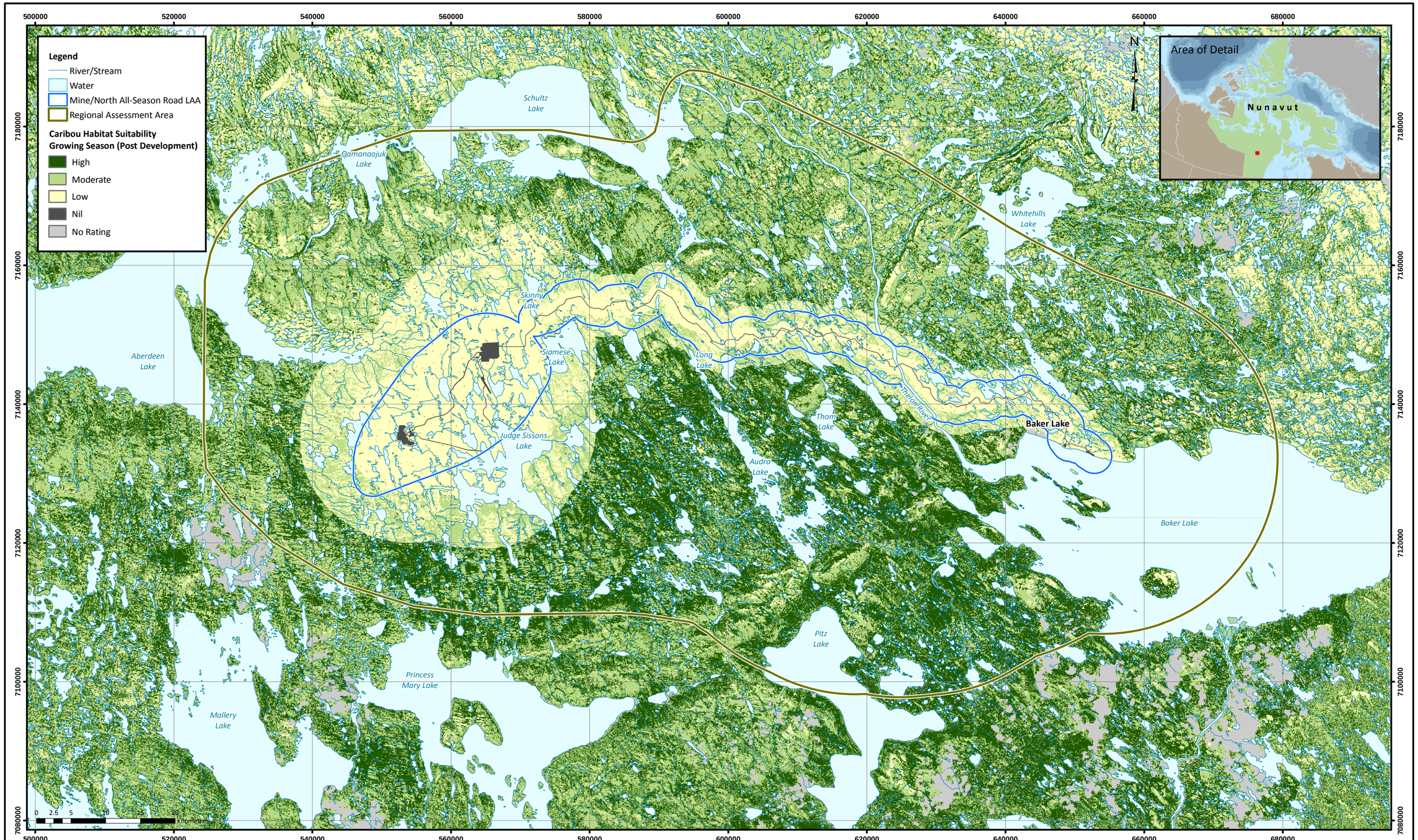
Season	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	RAA Effect	Herd Seasonal Range Effect
	Class	Value	ha	ha	ha	%	%
Growing	High	3	333,147	-643	-78,189	-23.7	
	Moderate	2	339,238	-987	-37,597	-11.4	
	Low	1	56,660	-50	115,786	204.3	
	Nil	0	251,110	-23	0	0.7	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,704**	**0**	**-11.4**	**-0.2**
Winter	High	3	288,774	-912	-76,619	-26.8	
	Moderate	2	379,679	-690	-42,083	-11.3	
	Low	1	311,701	-101	118,702	38.0	
	Nil	0	0	0	0	NA	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,704**	**0**	**-10.3**	**-0.3**

Muskox

Avoidance of habitat within the ZOI does not result in a loss of muskox habitat, but a reduction in the quality of habitat. During the growing season, the Project is expected to result in a 25% loss of available moderate quality habitat and a corresponding 199% increase of low quality habitat within the RAA (Figure 13.2-3). During the winter season, the Project is expected to result in a 25% loss of available high quality habitat, 22% loss of available moderate quality habitat and a corresponding 44% increase of low quality habitat within the RAA (Figure 13.2-4). This equates to an overall loss of 12% of growing season habitat units and 10% of winter season habitat units (Table 13.2-8). Comparing this change in available habitat within the RAA to the scale of the muskox Wildlife Management Unit MX/21, the reduced habitat availability corresponds to a reduction of 3.7% of growing season range and 3.1% of winter range.

Table 13.2-8 Muskox Habitat Baseline and Predicted Effects for the Mine Site and North All-Season Road

Season	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	RAA Effect	MU Effects
	Class	Value	ha	ha	ha	%	%
Growing	High	3	0	0	0	0.0	
	Moderate	2	647,737	-1,596	-161,876	-25.2	
	Low	1	81,308	-84	161,876	199.0	
	Nil	0	251,110	-23	0	0.7	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,704**	**0**	**-12.0**	**-3.7**
Winter	High	3	100,885	-206	-25,249	-25.2	
	Moderate	2	546,852	-1,390	-120,719	-22.3	
	Low	1	332,418	-108	145,968	43.9	
	Nil	0	0	0	0	NA	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,704**	**0**	**-10.1**	**-3.1**



Projection: NAD 1983 UTM Zone 14N
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File: 13.2-1_Habitat_Suitability_Growing_PD_Caribou.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-1
POST-DEVELOPMENT CARIBOU HABITAT SUITABILITY - GROWING SEASON
MINE AND NORTH ALL-SEASON ROAD

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project
AREVA

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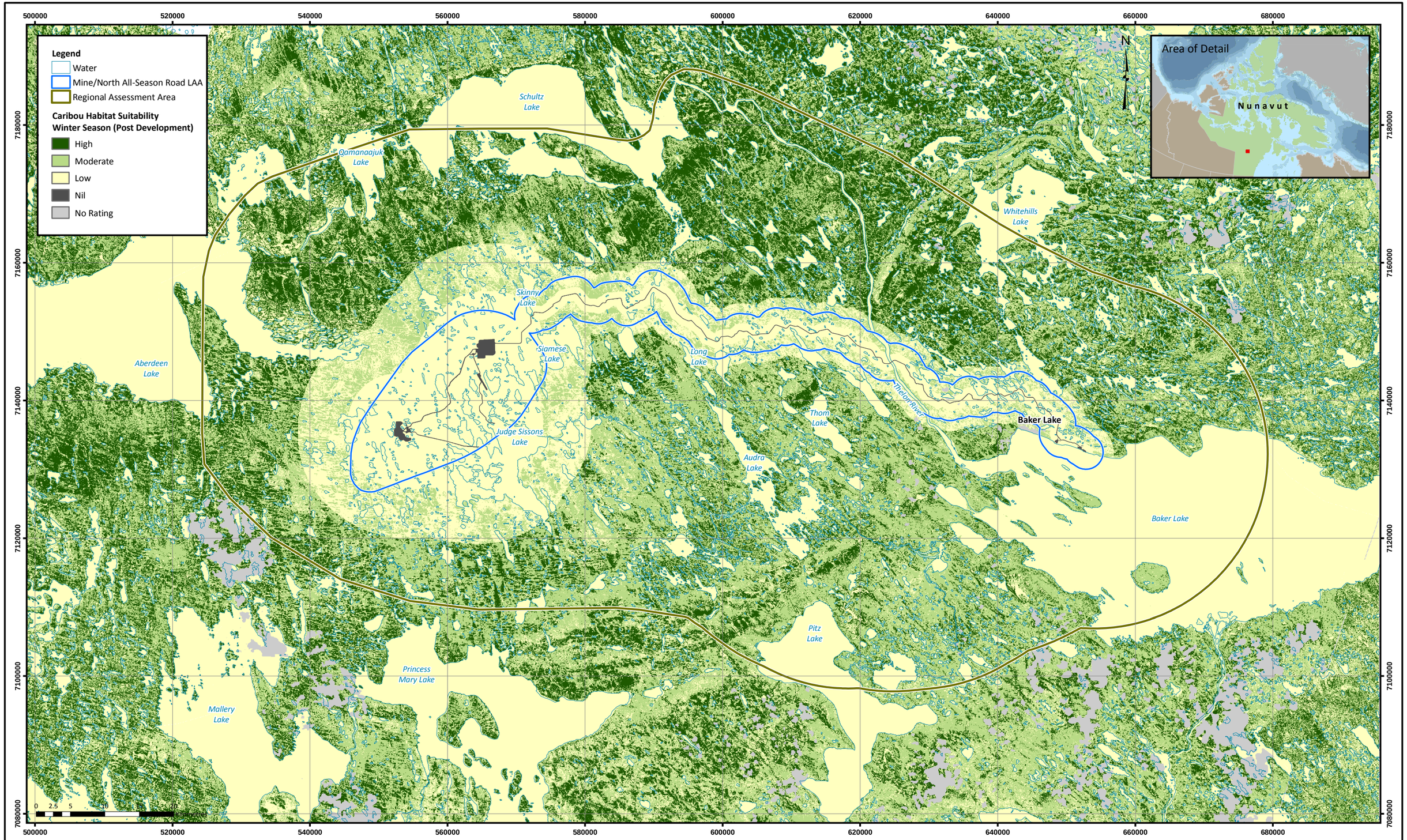

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-2_Habitat_Suitability_Winter_PD_Caribou_N_All-Season.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-2
POST-DEVELOPMENT CARIBOU HABITAT SUITABILITY - WINTER SEASON
MINE AND NORTH ALL-SEASON ROAD

ENVIRONMENTAL IMPACT STATEMENT
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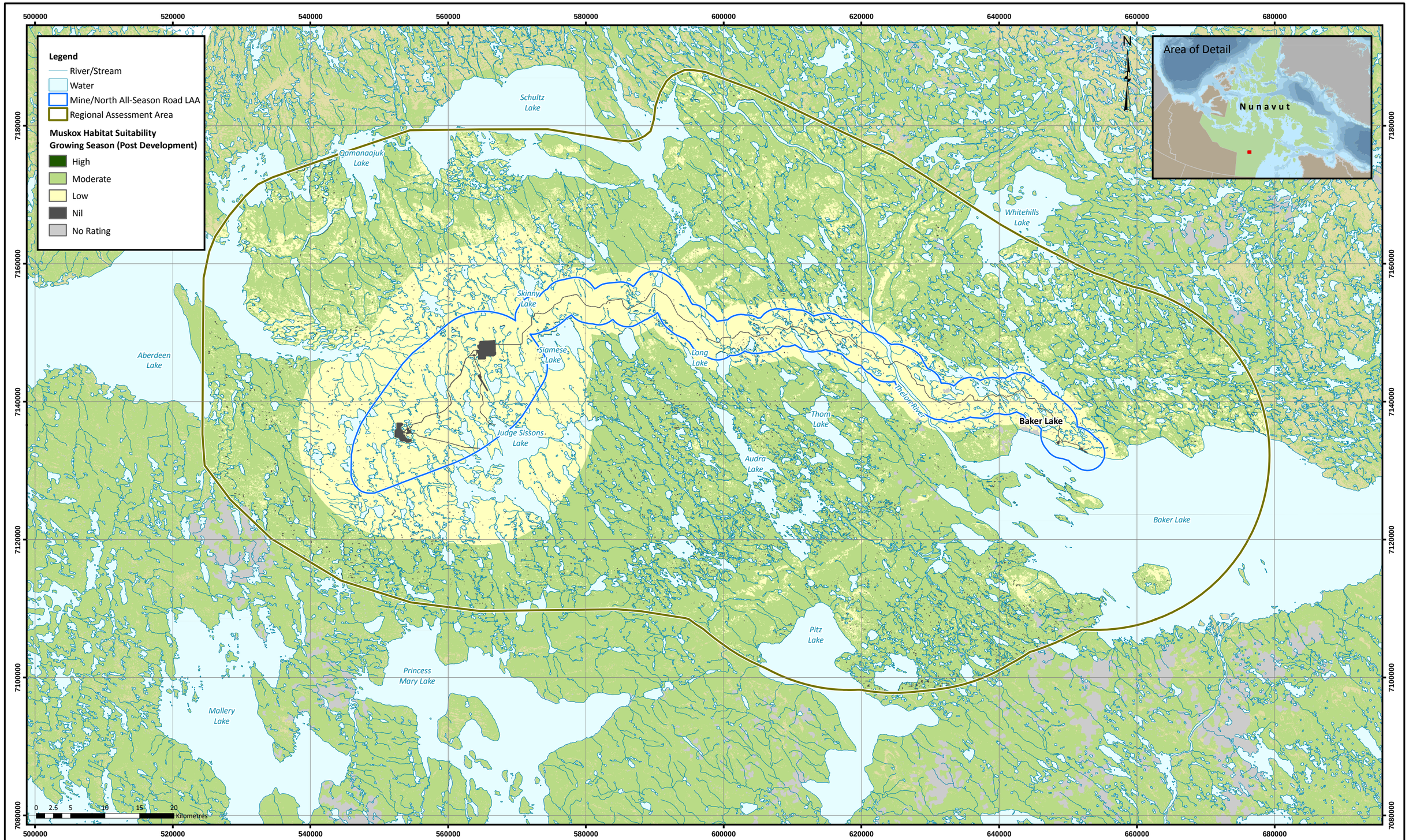

Projection: NAD 1983 UTM Zone 14N
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Date: 04/10/2012 Scale: 1:500,000
File: 13.2-3_Habitat_Suitability_Growing_PD_Muskox.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-3
POST-DEVELOPMENT MUSKOX HABITAT SUITABILITY - GROWING SEASON
MINE AND NORTH ALL-SEASON ROAD

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project

AREVA

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Legend

- Water
- Mine/North All-Season Road LAA
- Regional Assessment Area

Muskox Habitat Suitability
Winter Season (Post Development)

- High
- Moderate
- Low
- Nil
- No Rating

Area of Detail

Nunavut

N

Schultz Lake
Qamanaajuk Lake
Whitehills Lake
Skinny Lake
Siamese Lake
Long Lake
Aberdeen Lake
Thelon River
Thom Lake
Baker Lake
Judge Sissons Lake
Audra Lake
Baker Lake
Pitz Lake
Princess Mary Lake
Mallery Lake

0 2.5 5 10 15 20 Kilometres

500000 520000 540000 560000 580000 600000 620000 640000 660000 680000

7180000 7160000 7140000 7120000 7100000 7080000

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-4_Habitat_Suitability_Winter_PD_Muskox_N_All-Season.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-4
POST-DEVELOPMENT MUSKOX HABITAT SUITABILITY - WINTER SEASON
MINE AND NORTH ALL-SEASON ROAD

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13.2.2.5.2 Mine and South Winter Road

The mine site causes a direct loss of caribou and muskox habitat during both the growing and winter seasons; however, the South Winter Road only results in a direct loss of caribou or muskox habitat during the growing season because the road is decommissioned each year. The Project footprint results in a loss of 1,378 ha of available growing season habitat and a loss of 1,586 ha of available winter season habitat. This corresponds to 0.14% and 0.16% of available growing and winter season habitat, respectively.

Caribou

Avoidance of habitat within the ZOI does not result in a loss of caribou habitat, but a reduction in the quality of habitat. During the growing season, the habitat effects of the Project with the South Winter Road option are limited to the mine footprint and ZOI, resulting in a 15% loss of available high quality habitat, 9% loss of available moderate quality habitat and a corresponding 142% increase of low quality habitat within the RAA. During the winter season, the Project is expected to result in a 23% loss of available high quality habitat, 13% loss of available moderate quality habitat and a corresponding 37% increase of low quality habitat within the RAA (Figure 13.2-5). This equates to an overall loss of 8% of growing season habitat units and 10% of winter season habitat units (Table 13.2-9). Comparing this change in available habitat within the RAA to the range of the focal caribou herds, Baker Lake and Qamanirjuaq, the reduced habitat availability corresponds to a reduction of 0.2% of the Qamanirjuaq growing season range and 0.2% of the Baker Lake winter range.

Table 13.2-9 Caribou Habitat Baseline and Predicted Effects for the Mine Site and South Winter Road Option

Season	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	RAA Effect	Herd Seasonal Range Effect
	Class	Value	ha	ha	ha	%	%
Growing	High	3	333,147	548	-51,757	-15.4	
	Moderate	2	339,238	792	-31,617	-9.1	
	Low	1	56,660	16	80,663	142.4	
	Nil	0	251,110	22	2,711	0.5	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**1,378**	**0**	**-7.8**	**-0.2**
Winter	High	3	288,774	-777	-66,437	-23.3	
	Moderate	2	379,679	-631	-48,685	-13.0	
	Low	1	311,701	-178	115,122	36.9	
	Nil	0	0	0	0	NA	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,586**	**0**	**-9.6**	**-0.2**

Muskox

Avoidance of habitat within the ZOI does not result in a loss of muskox habitat, but a reduction in the quality of habitat. During the growing season, the habitat effects of the Project with the South Winter Road option are limited to the mine footprint and ZOI, resulting in a 17% loss of available moderate quality habitat and a corresponding 133% increase of low quality habitat within the RAA. During the winter season, the Project with the South Winter Road option is expected to result in a 24% loss of available high quality habitat, 22% loss of available moderate quality habitat and a corresponding 43% increase of low quality habitat within the RAA (Figure 13.2-6). This equates to an overall loss of 8% of growing season habitat units and 10% of winter season habitat units (Table 13.2-10). Comparing this change in available habitat within the RAA to the scale of the muskox Wildlife Management Unit MX/21, the reduced habitat availability corresponds to a reduction of 2.5% of growing season range and 3.0% of winter range.

Table 13.2-10 Muskox Habitat Baseline and Predicted Effects for the Mine Site and South Winter Road Option

Season	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	MU Effect
	Class	Value	ha	ha	ha	%	%
Growing	High	3	0	0	0	0.0	
	Moderate	2	647,737	-1,316	-107,820	-16.8	
	Low	1	81,308	-40	107,820	132.6	
	Nil	0	251,110	-22	0	0.5	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,378**	**0**	**-8.0**	**-2.5**
Winter	High	3	100,885	-192	-24,384	-24.4	
	Moderate	2	546,852	-1,234	-117,001	-21.6	
	Low	1	332,418	-161	141,386	42.5	
	Nil	0	0	0	0	NA	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,586**	**0**	**-9.8**	**-3.0**

Legend

- River/Stream
- Water
- Mine/South Winter Road LAA
- Regional Assessment Area

Caribou Habitat Suitability
Winter Season (Post Development)

- High
- Moderate
- Low
- Nil
- No Rating

Area of Detail

Nunavut

N

Schultz Lake
Qamanaajuk Lake
Whitehills Lake
Skinny Lake
Siamese Lake
Long Lake
Aberdeen Lake
Thelon River
Thom Lake
Baker Lake
Judge Sissons Lake
Audra Lake
Pitz Lake
Princess Mary Lake
Mallery Lake

500000 520000 540000 560000 580000 600000 620000 640000 660000 680000

7180000 7160000 7140000 7120000 7100000 7080000

0 2.5 5 10 15 20 Kilometers

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-5_Habitat_Suitability_Winter_PD_Caribou_SWinter.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-5
POST-DEVELOPMENT CARIBOU HABITAT SUITABILITY - WINTER SEASON
MINE AND SOUTH WINTER ROAD

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Legend

- River/Stream
- Water
- Mine/South Winter Road LAA
- Regional Assessment Area

Muskox Habitat Suitability
Winter Season (Post Development)

- High
- Moderate
- Low
- Nil
- No Rating

N

Schultz Lake
Qamanaajuk Lake
Whitehills Lake
Skinny Lake
Aberdeen Lake
Siamese Lake
Long Lake
Thom Lake
Thelon River
Baker Lake
Judge Sissons Lake
Audra Lake
Baker Lake
Pitz Lake
Princess Mary Lake
Mallery Lake

0 2.5 5 10 15 20 Kilometres

500000 520000 540000 560000 580000 600000 620000 640000 660000 680000

7180000 7160000 7140000 7120000 7100000 7080000

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-6_Habitat_Suitability_Winter_PD_Muskox_SWinter.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-6
POST-DEVELOPMENT MUSKOX HABITAT SUITABILITY - WINTER SEASON
MINE AND SOUTH WINTER ROAD

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13.2.2.5.3 Mine and North Winter Road

The mine site causes a direct loss of caribou and muskox habitat during both growing and winter seasons; however, the North Winter Road only results in a direct loss of caribou or muskox habitat during the growing season because the road is decommissioned each year. The Project footprint results in a loss of 1,378 ha of available growing season habitat and a loss of 1,576 ha of available winter season habitat. This corresponds to roughly 0.14% and 0.16% of available growing and winter season habitat, respectively.

Caribou

Avoidance of habitat within the ZOI does not result in a loss of caribou habitat, but a reduction in the quality of habitat. During the growing season, the habitat effects of the Project with the North Winter Road option are limited to the mine footprint and ZOI, with a 15% loss of available high quality habitat, 9% loss of available moderate quality habitat and a corresponding 142% increase of low quality habitat within the RAA. During the winter season, the Project is expected to result in a 25% loss of available high quality habitat, 12% loss of available moderate quality habitat and a corresponding 37% increase of low quality habitat within the RAA (Figure 13.2-7). This equates to an overall loss of 8% of growing season habitat units and 10% of winter season habitat units (Table 13.2-11). Comparing this change in available habitat within the RAA to the range of the focal caribou herds, Baker Lake and Qamanirjuaq, the reduced habitat availability corresponds to a reduction of 0.2% of the Qamanirjuaq growing season range and 0.3% of the Baker Lake winter range.

Table 13.2-11 Caribou Habitat Baseline and Predicted Effects for the Mine Site and North Winter Road Option

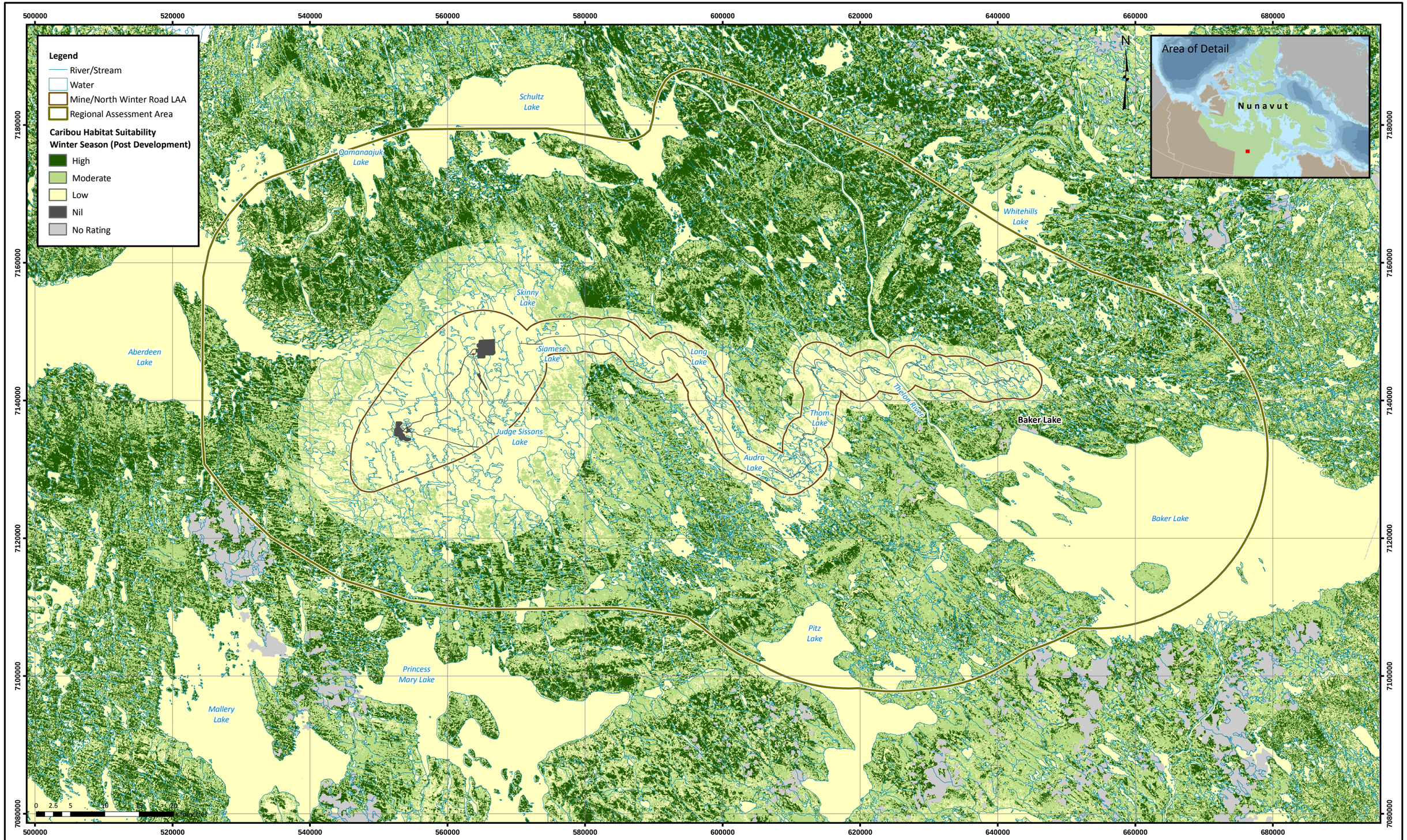
Season	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	Herd Seasonal Range Effect
	Class	Value	ha	ha	ha	%	%
Growing	High	3	333,147	-548	-50,661	-15.4	
	Moderate	2	339,238	-792	-30,033	-9.1	
	Low	1	56,660	-16	80,694	142.4	
	Nil	0	251,110	-22	0	0.5	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,378**	**0**	**-7.8**	**-0.2**
Winter	High	3	288,774	-774	-71,396	-25.0	
	Moderate	2	379,679	-611	-45,386	-12.1	
	Low	1	311,701	-191	116,782	37.4	
	Nil	0	0	0	0	NA	
	No Rating		2,583	0	0	0.0	
	Total		**982,738**	**-1,576**	**0**	**-9.9**	**-0.3**

Muskox

Avoidance of habitat within the ZOI does not result in a loss of muskox habitat, but a reduction in the quality of habitat. During the growing season, the habitat effects of the Project with the North Winter Road option are limited to the mine footprint and ZOI, resulting in a 17% loss of available moderate quality habitat and a corresponding 133% increase of low quality habitat within the RAA. During the winter season, the Project is expected to result in a 24% loss of available high quality habitat, 22% loss of available moderate quality habitat and a corresponding 43% increase of low quality habitat within the RAA (Figure 13.2-8). This equates to an overall loss of 8% of growing season habitat units and 10% of winter season habitat units (Table 13.2-12). Comparing this change in available habitat within the RAA to the scale of the muskox Wildlife Management Unit MX/21, the reduced habitat availability corresponds to a reduction of 2.5% of growing season range and 3.1% of winter range.

Table 13.2-12 Muskox Habitat Baseline and Predicted Effects for the Mine Site and North Winter Road Option

Season	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	MU Effect
	Class	Value	ha	ha	ha	%	%
Growing	High	3	0	0	0	0.0	
	Moderate	2	647,737	-1,316	-107,820	-16.8	
	Low	1	81,308	-40	107,820	132.6	
	Nil	0	251,110	-22	0	0.5	
	No Rating		2,583	0	0	0.0	
	Total		982,738	-1,378	0	-8.0	**-2.5**
Winter	High	3	100,885	-190	-25,746	-25.7	
	Moderate	2	546,852	-1,212	-119,369	-22.1	
	Low	1	332,418	-173	145,115	43.6	
	Nil	0	0	0	0	NA	
	No Rating		2,583	0	0	0.0	
	Total		982,738	-1,576	0	-10.1	**-3.1**



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-7_Habitat_Suitability_Winter_PD_Caribou_NWinter.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-7
POST-DEVELOPMENT CARIBOU HABITAT SUITABILITY - WINTER SEASON
MINE AND NORTH WINTER ROAD

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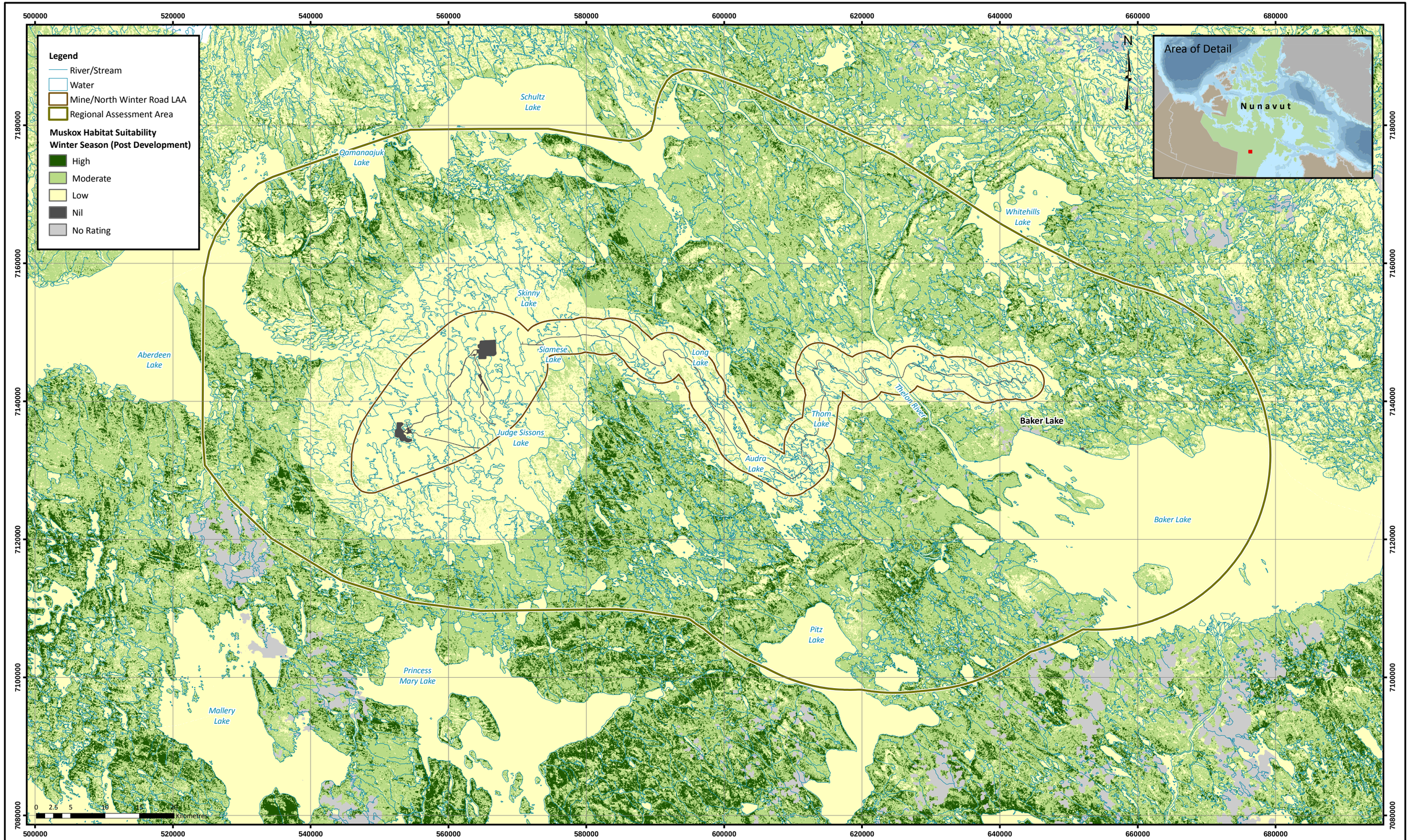

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-8_Habitat_Suitability_Winter_PD_Muskox_NWinter.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-8
POST-DEVELOPMENT MUSKOX HABITAT SUITABILITY - WINTER SEASON
MINE AND NORTH WINTER ROAD

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13.2.2.6 Determination of Significance for Change in Habitat Availability

The Kiggavik Project will have a not significant effect on the availability of caribou and muskox growing and winter season habitat. Loss in habitat availability across the seasonal ranges does not exceed the 5% significance threshold. For caribou, the mine and all road options will cause a habitat loss of less than or equal to 0.3% within the seasonal ranges of the focal herds. For muskox, the mine and all road options will cause a habitat loss of less than 5% within muskox management unit MX/21.

13.2.2.7 Summary of Project Residual Environmental Effects for Change in Habitat Availability

Table 13.2-13 summarizes residual environmental effects from the Project on caribou and muskox habitat. The magnitude of the Project effects is predicted to be moderate during construction, operation, and final closure phases. While the size of the Project footprint is very small at the scale of the affected caribou and muskox herd/population's ranges, mine-associated activities will reduce the availability of habitat up to 14 km from the Project footprint resulting in a moderate loss of habitat. After final closure, the Project footprint will remain unusable as foraging habitat, consequently the magnitude of the predicted effect remains low beyond the life of the Project. There is general consensus that human disturbance causes large wildlife to avoid areas at the scale of kilometres. The extent of avoidance can be vary according to local environmental and topographic conditions, consequently, the confidence in the predicted effect of the Kiggavik Project on caribou and muskox is moderate.

The North All-Season Road will have the largest footprint and disturbance of all road options. This will cause the greatest reduction in growing season habitat compared to other road options because of the larger footprint and greater time (eight months) of disturbance. The winter roads will be active roughly three winter months each year.

Table 13.2-13 Summary of Residual Environmental Effects for Change in Habitat Availability for Caribou and Muskox

Project Phase	Mitigation/ Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in Caribou and Muskox Habitat — Mine with North All-Season Road Option												
Construction	Dust management; Minimize Project footprint; Progressive reclamation	N	M	R	MT	C	R	U	N	N/A	M	Contribution to collaring program
Operation		N	M	R	MT	C	R	U	N	N/A	M	
Final Closure		N	M	R	MT	C	R	U	N	N/A	M	None required
Change in Caribou and Muskox Habitat — Mine with South or North Winter Road Options												
Construction	Dust management; Minimize Project footprint; Progressive reclamation	N	M	R	MT	C	R	U	N	N/A	M	Collaring program
Operation		N	M	R	MT	C	R	U	N	N/A	M	Collaring program
Final Closure		N	M	R	MT	C	R	U	N	N/A	M	None required

Table 13.2-13 Summary of Project Residual Environmental Effects for Change in Habitat Availability for Caribou and Muskox (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible: No anticipated effect on wildlife species

L Low: Observable effect on wildlife species but not likely to affect the species' sustainability in the Project area

M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the region

H High: Measurable effect on wildlife species but that will likely affect the species' sustainability in the region

Geographic Extent:

S Site-specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities

13.2.2.8 Compliance and Environmental Monitoring for Change in Habitat Availability

AREVA will monitor the Project footprint on an annual basis to assess the footprint area for changes in habitat availability. Continued contributions to a government-led caribou collaring program will provide future information on the response of caribou to habitat disturbance in the Kivalliq region.

13.2.3 Assessment of Change in Movement

The focus of this assessment is on caribou migration between calving grounds and winter range during the spring and fall migration periods. Caribou herds that have the potential to occur within the RAA include three tundra wintering herds (i.e., Baker Lake, Lorillard, and Wager Bay) and three migratory herds (i.e., Qamanirjuaq, Beverly, and Ahiak). The long distance seasonal migrations—performed by migratory caribou and, to a lesser degree, by Resident caribou between winter ranges and calving grounds—are unique among Arctic terrestrial mammals and are important for the continued existence of migratory herds. Reducing Project effects on caribou migration is an important component to address.

Several areas within the RAA have been identified as known caribou water crossings. Water crossings are important during the ice-free season for caribou because they are terrain bottlenecks where caribou movement is most restricted.

Muskox move at relatively small scales (i.e., no long distance migration) between available habitats within their range and their movements are less directional and predictable than those of caribou. An assumption made during the assessment was mitigation measures implemented to reduce Project effects on caribou movement would also reduce potential effects to muskox.

13.2.3.1 Analytical Methods for Change in Movement

Information used to assess Project effects on caribou movement included GNDoE caribou collar data, IQ studies, and the baseline wildlife studies. Collar data used for the assessment is summarized in Table 13.2-14. The data were restricted to migratory seasons (when caribou movement is more directional compared to other seasons), and they are moving between their calving and wintering areas. During other seasons, their movement is based on the availability of suitable habitat.

The assessment of Project effects on habitat availability was completed above. The migratory seasons for caribou are spring migration to calving grounds and fall movements to wintering ranges. During spring migration, female caribou migrate in large numbers to calving grounds to give birth. Their routes and calving grounds are relatively consistent among years, but long term studies of the caribou herds in Nunavut and Northwest Territories show that caribou calving grounds are somewhat dynamic (Nagy et al. 2011).

The potential effect of the Project on caribou movement has been assessed by looking for possible interactions with the Project during spring and fall migrations. Spring migration is March 16 to May 25, and fall migration is September 16 to October 31 (see Tier 3, Appendix 6C). To complete the assessment using collar data, three assumptions were made: 1) the collar data are representative of the entire herd; 2) Caribou movement between collar relocation is a straight line; and 3) Caribou movement during the collaring period is representative of both current and future movements.

To assess the likelihood of the Project interacting with caribou herds, the available collar information (Table 13.2-14) was analyzed in a geographic information system: the number of caribou that crossed the study areas (to get an indication of potential caribou interaction with the Kiggavik Project during migration) and all water crossings within 10 km of each of the Project options.

Table 13.2-14 Caribou Collar Data by Herd

Herd	Number of Collared Animals	Average Frequency of Transmission	Timeframe
Baker Lake (resident)	43	1 per day	15 May 2008 to 12 July 2011
Qamanirjuaq	112	1 per day	1 April 1993 to 9 July 2011
Lorillard	20	1 per day	26 April 1999 to 12 August 2008
Wager Bay	20	1 per day	19 April 2000 to 31 December 2006
Beverly and Ahiak1,2	68	1 per day	8 March 2006 to 31 March 2011
NOTES: [1] The raw data for Beverly and Ahiak has two transmissions per day, but for this analysis, only one per day was used. [2] Beverly and Ahiak herds are closely associated; there are no attributes in the data that allow the two herds to be differentiated.			
SOURCES: Government of Nunavut and Government of Northwest Territories			

13.2.3.2 Baseline Conditions for Change in Movement

Caribou herds occurring within mainland Nunavut are grouped into two behaviourally different types of caribou: migratory and tundra wintering caribou (Nagy et al. 2011). Migratory caribou include the Ahiak, Beverly and Qamanirjuaq herds. Tundra wintering (resident) caribou include the Baker Lake, Lorillard and Wager Bay herds. All caribou herds perform seasonal migrations between their calving areas and winter range, but the migratory caribou herds migrate much further to and from their wintering ranges in southern Nunavut and Northwest Territories, and northern Manitoba and Saskatchewan. While caribou migrations and use of calving areas are relatively consistent among years, there is strong evidence that caribou herds are more dynamic than previously thought (Nagy et al. 2011; Boulet et al. 2007; Hinkes et al. 2005).

The distribution of collared caribou during the migratory seasons is generally outside of the RAA. Qamanirjuaq collared caribou occur predominately south of the RAA during the spring and fall migration periods (Figures 13.2-9 and 13.2-10). Beverly and Ahiak collared caribou occur

mostly west of the RAA during spring and fall migrations (Figures 13.2-11 and 13.2-12). Wager Bay collared caribou occur mostly north and east of the RAA during spring and fall migrations (Figures 13.2-13 and 13.2-14). Lorillard collared caribou occur mostly east of the RAA during spring and fall migrations (Figures 13.2-15 and 13.2-16). Baker Lake (resident) collared caribou occur immediately north and within the RAA during spring and fall migrations (Figures 13.2-17 and 13.2-18).

13.2.3.3 Effect Mechanism and Linkages for Change in Movement

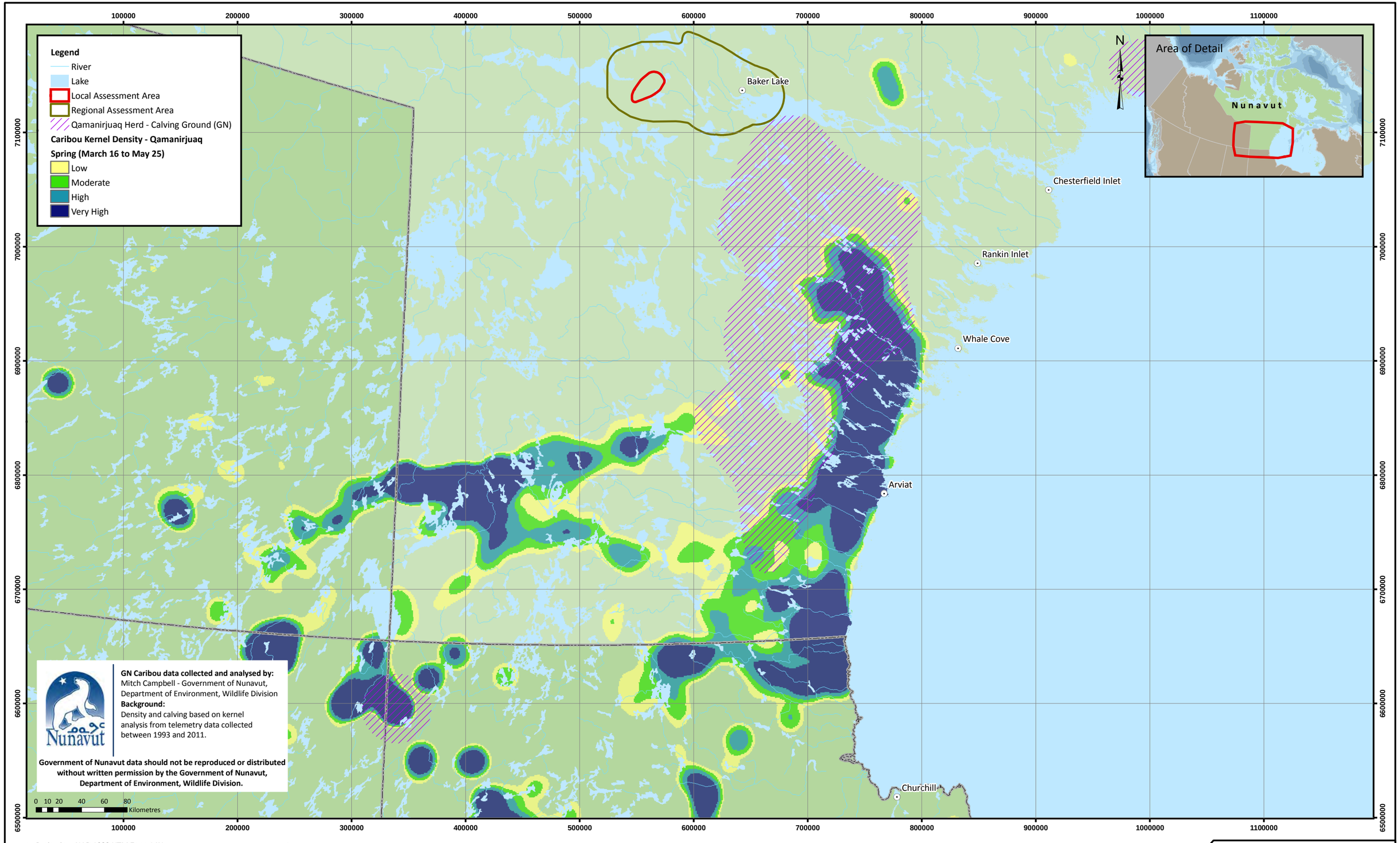
Caribou movement can be affected by human developments that block or restrict movement of caribou across Project infrastructure such as buildings, open pits, pipelines, and fencing (Klein 1971; Mahoney and Schaefer 2002). The Kiggavik Project could affect caribou migration to calving grounds in spring or winter range in fall through construction of infrastructure and human activities that change, restrict or block caribou movement across the landscape.

Migratory barren-ground caribou migrate as a strategy to access high quality seasonal habitats and avoid predation. Caribou migrations are timed so they reach their calving grounds in time to give birth and they move south so they are able to avoid harsh weather conditions and access suitable winter forage. Changes to migration could have implications on reproductive success and survival. Consequently, changes to caribou migration could affect regional caribou populations.

Large linear structures have the greatest potential to affect caribou movement; non-linear features (e.g., camp or pit) can be bypassed easily by caribou. The Project's proposed linear infrastructure that has the greatest potential to block caribou movement includes road embankments; pipeline, vehicles travelling along the access roads; and possibly fencing. Most of this infrastructure will be located within the mining sites and airstrip.

Water crossings were identified within the RAA. Designated water crossing are identified in the DIAND Caribou Protection Measures. Further crossings were identified from IQ and baseline studies. IQ indicates several caribou movement areas in proximity to the Project. Project infrastructure or activities that block movement through these areas could result in Project effects on caribou.

Caribou spring and fall migration occurs 16 March to 25 May and 16 September to 31 October, respectively (BQCMB 1999). The North All-Season Road will be usable for eight months of the year, so activity along the road will overlap with caribou moving through the area during spring and fall migrations. The winter road options will be operational for less than 90 days per year, presumably from December to March, so the timing of seasonal construction and use of the winter access roads will overlap with spring migration in March but will not overlap with fall migration.



GN Caribou data collected and analysed by:
Mitch Campbell - Government of Nunavut, Department of Environment, Wildlife Division
Background:
Density and calving based on kernel analysis from telemetry data collected between 1993 and 2011.

Government of Nunavut data should not be reproduced or distributed without written permission by the Government of Nunavut, Department of Environment, Wildlife Division.

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-9_Caribou_Density_Qamanirjuaq_Spring.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-9
QAMANIRJUAQ CARIBOU DENSITY - SPRING

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Legend
- River
- Lake
- Local Assessment Area
- Regional Assessment Area

Caribou Kernel Density - Qamanirjuaq Fall and Fall Rut (Sept. 16 to Oct. 31)
- Low
- Moderate
- High
- Very High

Baker Lake
Chesterfield Inlet
Rankin Inlet
Whale Cove
Arviat
Churchill

N

Area of Detail
Nunavut

GN Caribou data collected and analysed by:
Mitch Campbell - Government of Nunavut, Department of Environment, Wildlife Division
Background:
Density based on kernel analysis from telemetry data collected between 1993 and 2011.

Government of Nunavut data should not be reproduced or distributed without written permission by the Government of Nunavut, Department of Environment, Wildlife Division.

0 10 20 40 60 80 Kilometres

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-10_Caribou_Density_Qamanirjuaq_fall.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-10
QAMANIRJUAQ CARIBOU DENSITY - FALL AND FALL RUT

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Legend

- River
- Lake
- Local Assessment Area
- Regional Assessment Area
- Ahiak Herd - Calving Ground (GNWT)
- Beverly Herd - Calving Ground*

Caribou Kernel Density - Beverly and Ahiak ^

Spring (March 16 to May 25)

- Low
- Moderate
- High
- Very high

*Derived from citations within BQCMB 1999, summarising information based on surveys from 1948 to 1990.

^ Density and calving based on kernel analysis from telemetry data collected between 2006 and 2011.

Umingmaktok

Bathurst Inlet

Baker Lake

Rankin Inlet

Whale Cove

N

Area of Detail

Nunavut

0 10 20 40 60 80 Kilometres

-300000 -200000 -100000 0 100000 200000 300000 400000 500000 600000 700000 800000

7500000 7400000 7300000 7200000 7100000 7000000 6900000

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-11_Caribou_Density_Beverly_Ahiak_Spring.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-11
BEVERLY AND AHIAK CARIBOU DENSITY - SPRING

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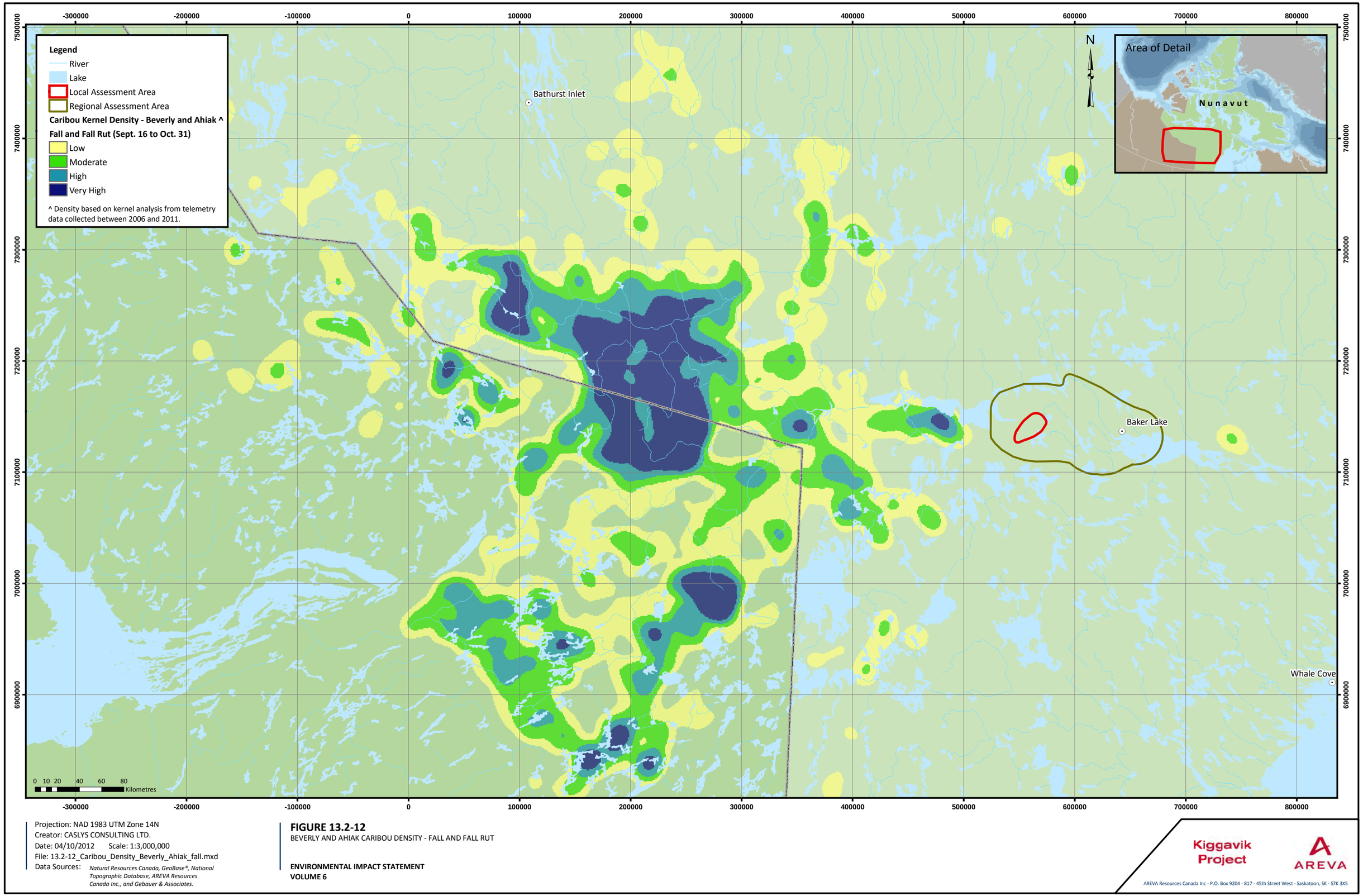

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-12_Caribou_Density_Beverly_Ahiak_fall.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-12
BEVERLY AND AHIAK CARIBOU DENSITY - FALL AND FALL RUT

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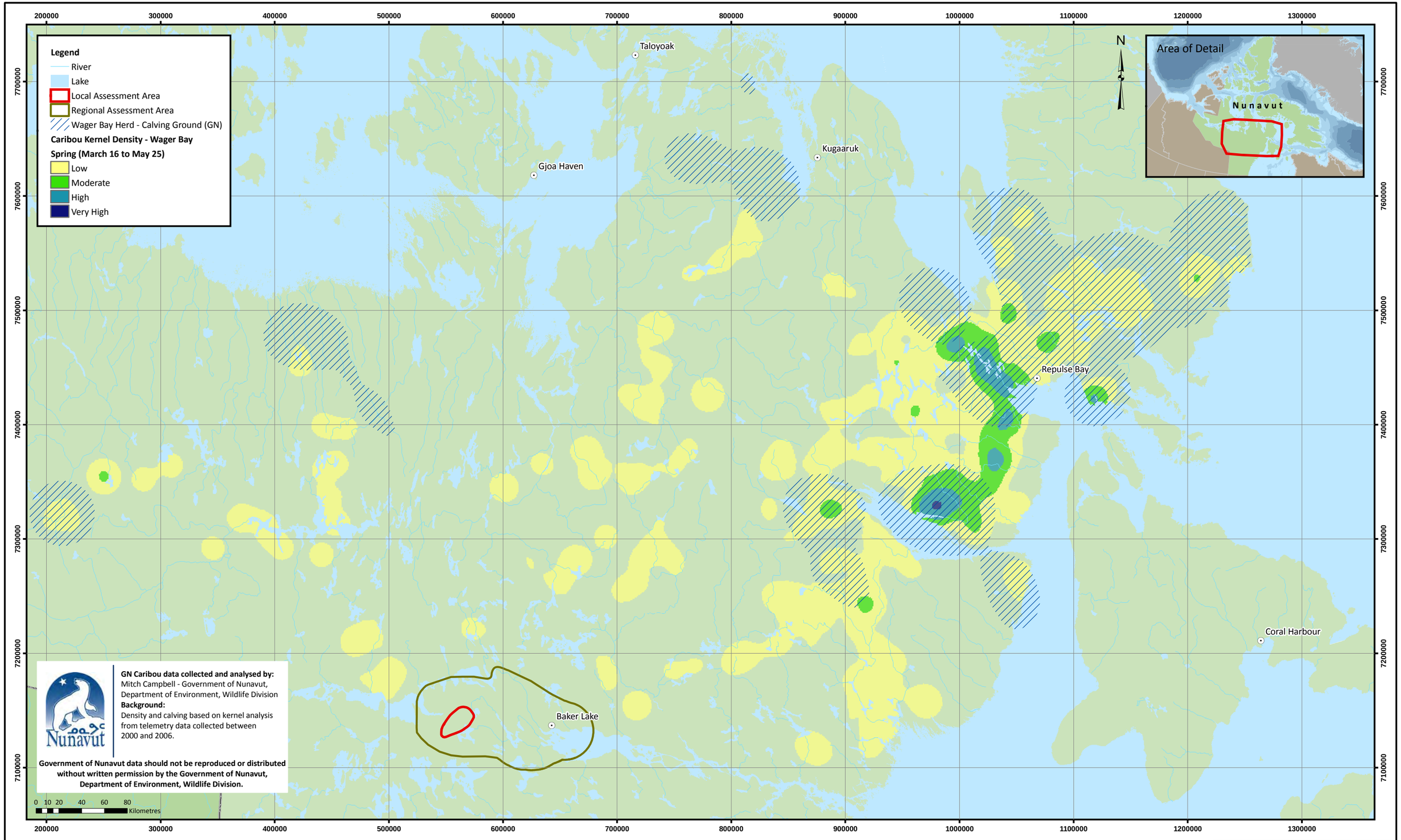

GN Caribou data collected and analysed by:
Mitch Campbell - Government of Nunavut, Department of Environment, Wildlife Division
Background:
Density and calving based on kernel analysis from telemetry data collected between 2000 and 2006.

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Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-13_Caribou_Density_Wager_Bay_Spring.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-13
WAGER BAY CARIBOU DENSITY - SPRING

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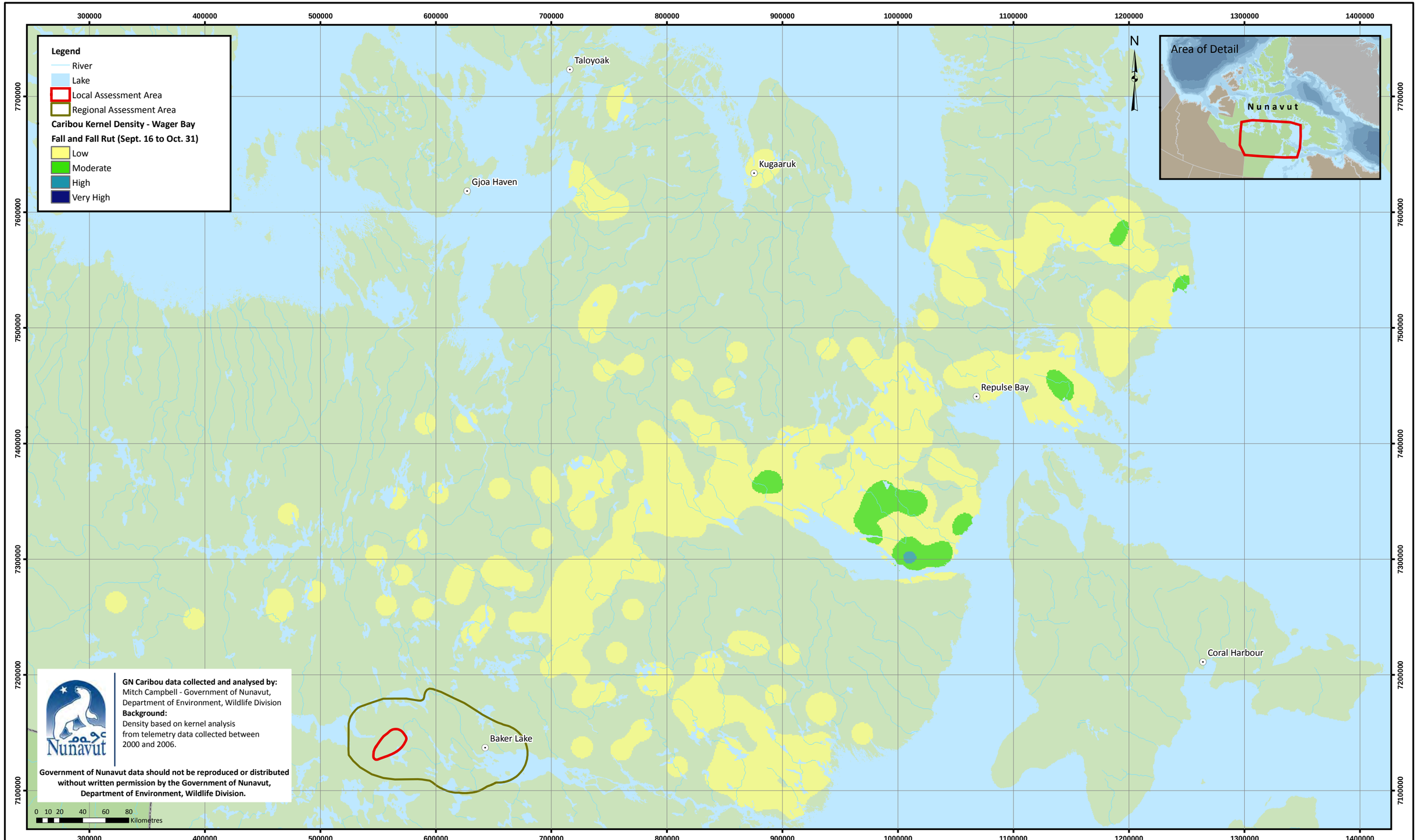

GN Caribou data collected and analysed by:
Mitch Campbell - Government of Nunavut,
Department of Environment, Wildlife Division
Background:
Density based on kernel analysis
from telemetry data collected between
2000 and 2006.

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Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-14_Caribou_Density_Wager_Bay_fall.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-14
WAGER BAY CARIBOU DENSITY - FALL AND FALL RUT

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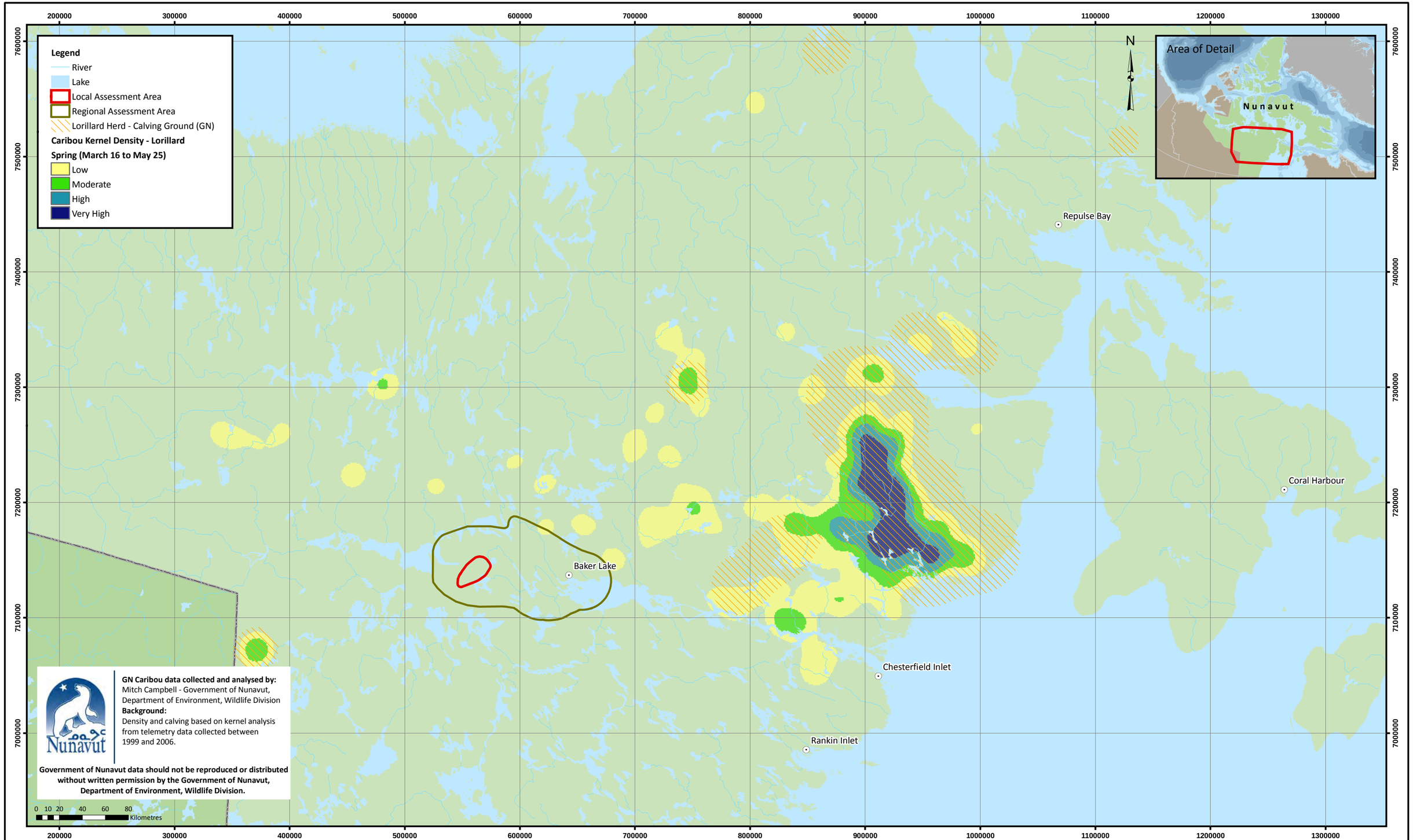

GN Caribou data collected and analysed by:
Mitch Campbell - Government of Nunavut, Department of Environment, Wildlife Division
Background:
Density and calving based on kernel analysis from telemetry data collected between 1999 and 2006.

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Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-15_Caribou_Density_Lorillard_Spring.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-15
LORILLARD CARIBOU DENSITY - SPRING

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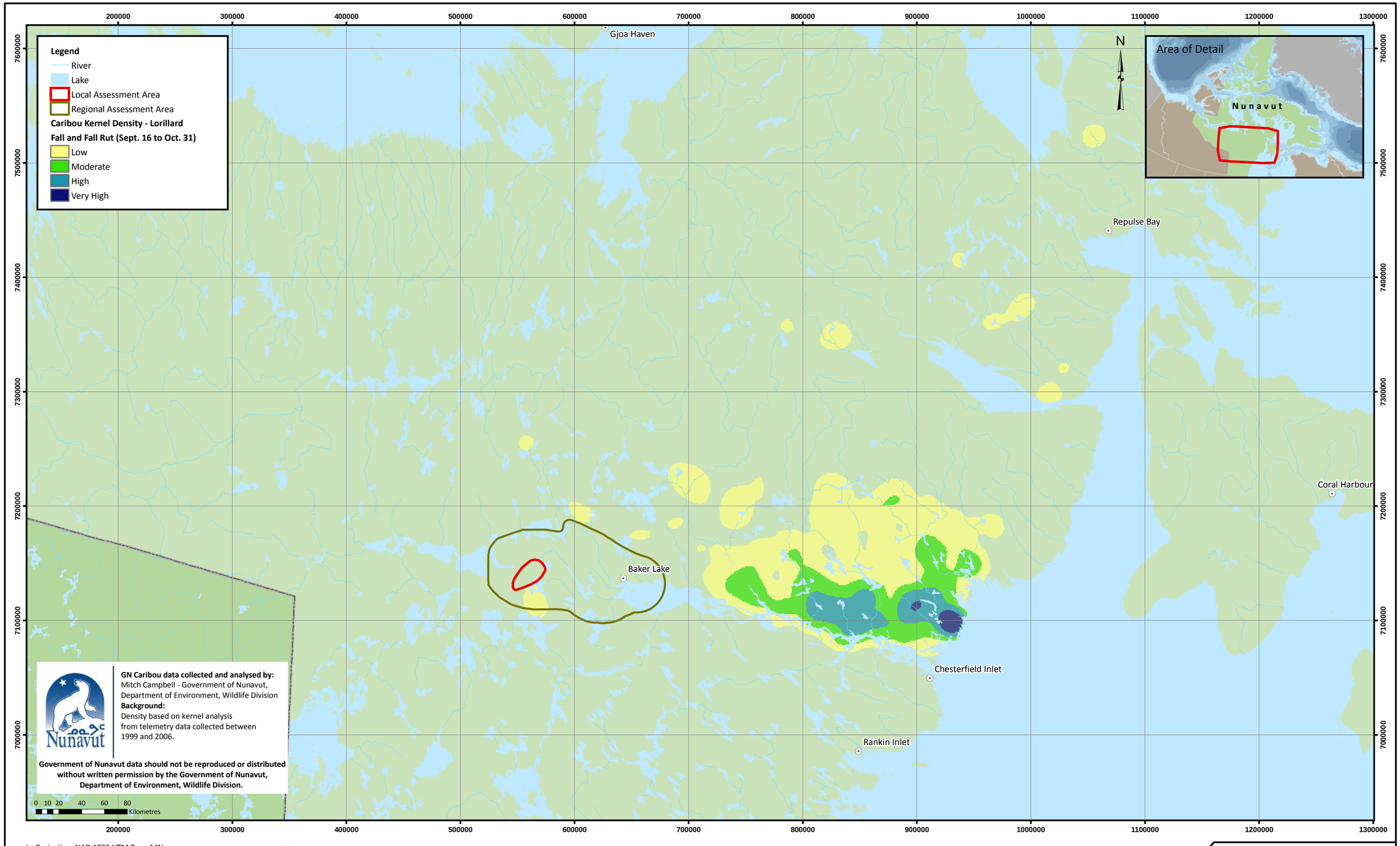

GN Caribou data collected and analysed by:
Mitch Campbell - Government of Nunavut,
Department of Environment, Wildlife Division
Background:
Density based on kernel analysis
from telemetry data collected between
1999 and 2006.

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Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-16_Caribou_Density_Lorillard_fall.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-16
LORILLARD CARIBOU DENSITY - FALL AND FALL RUT

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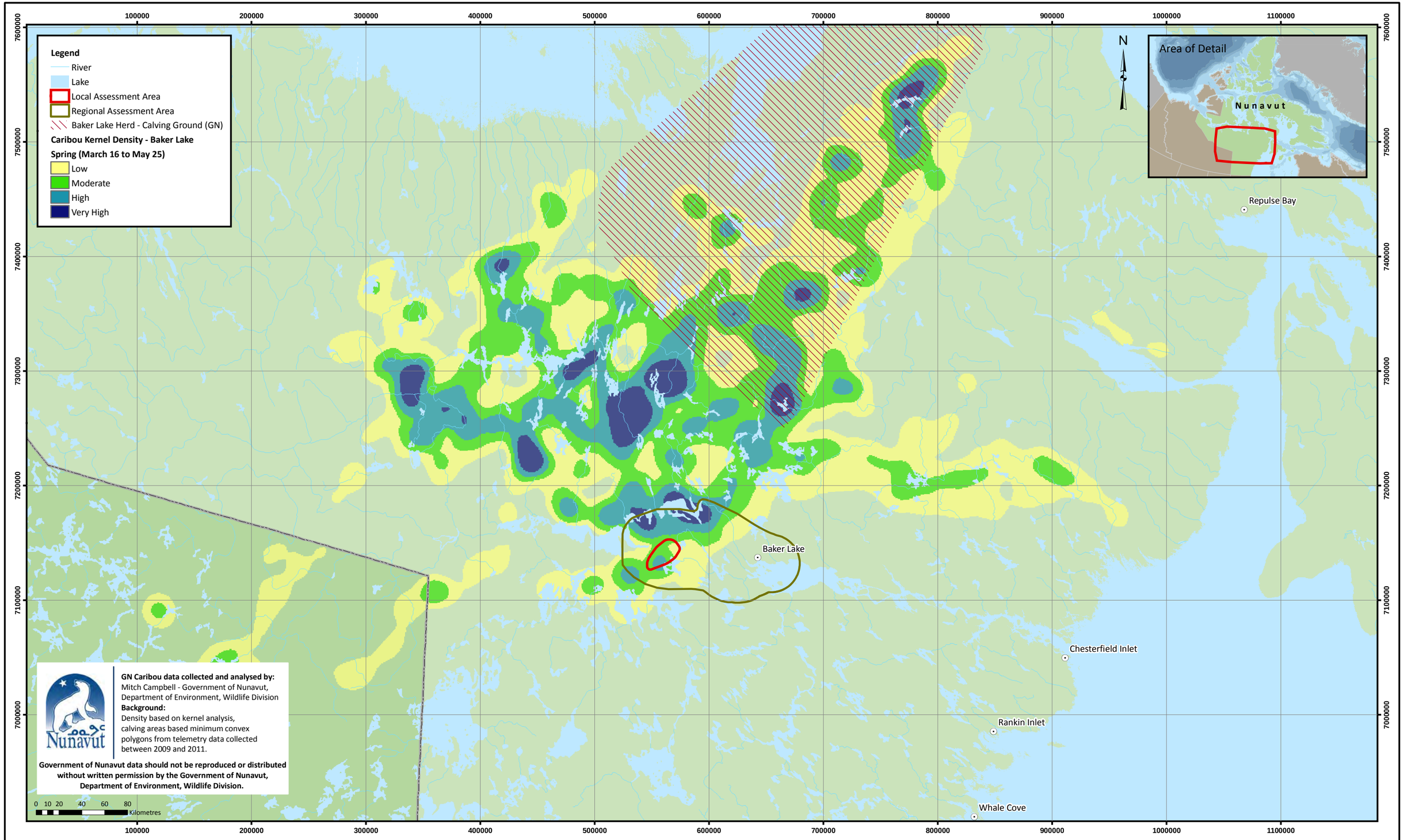

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-17_Caribou_Density_Baker_Lake_Spring.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-17
BAKER LAKE CARIBOU DENSITY - SPRING

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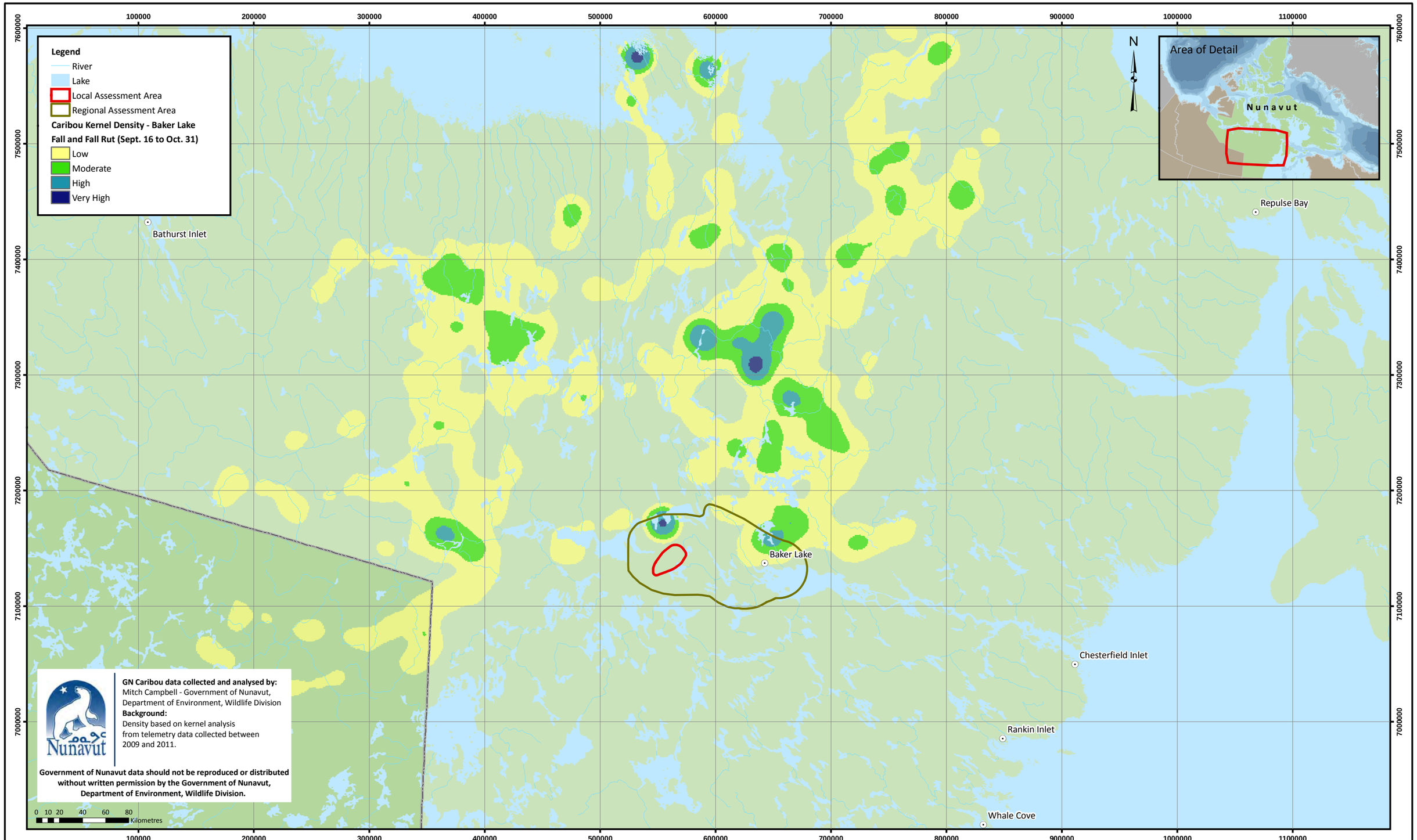

GN Caribou data collected and analysed by:
Mitch Campbell - Government of Nunavut, Department of Environment, Wildlife Division
Background:
Density based on kernel analysis from telemetry data collected between 2009 and 2011.

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Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.2-18_Caribou_Density_Baker_Lake_fall.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 13.2-18
BAKER LAKE CARIBOU DENSITY - FALL AND FALL RUT

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13.2.3.4 Mitigation Measures and Project Design for Change in Movement

AREVA will mitigate effects on caribou movement by:

- reducing road embankment height of the North All-Season Road to prevent visual obstruction for migrating caribou, as well as to facilitate ease of crossing
- practising snow management that avoids long continuous cuts or piles of snow that could restrict spring migration across roadways; there are no apparent movement areas across the road in the winter, but snowbank passageways can be created on an as-need basis.
- using fine-grained materials on the road surface and road slopes to create a good travel surface for caribou (or other wildlife) attempting to cross the road (i.e., road materials won't cause potential injury or difficulty for animals when crossing)
- siting Project components and activities a minimum of 10 km from designated water crossing to preventing disturbing them, or causing potential avoidance of the crossing by migrating caribou
- minimizing the use of physical barriers such as fencing and, where required, minimize the lengths of fencing unless required for safety
- implementing temporary road shutdowns if large numbers of caribou are observed migrating through the area

The DIAND Caribou Protection Measures are intended to mitigate potential Project effects. The measures include protection for caribou during the calving and post-calving seasons, 15 May to 1 September. During this period, the caribou protection measures restrict construction of camps, fuel caching or blasting within 10 km of crossings (Protection Measure 4a); and diamond drilling within 5 km of crossings (Protection Measure 4b). Also, the protection measures state the Project cannot "block or cause substantial diversion to migration" (Protection Measure 3a) and will "cease activities that may interfere with migration" (Protection Measure 3b). This can include suspending flights of 300 m agl when caribou cows and calves are present between May 15 and July 15 (Protection Measure 2bii).

13.2.3.5 Residual Effects for Change in Movement

Collar data from the migratory caribou herds during the migratory period and the known locations of the current calving grounds suggests that few caribou will interact with the Project during the migration seasons. Therefore, the likelihood of the Project restricting caribou movement is relatively low. All migratory caribou cross many natural barriers during migrations (e.g., large river valleys, mountain ranges) and many herds cross human infrastructure. While caribou may spend less time near the infrastructure, the infrastructure is not a barrier to migrations.

During the migratory seasons, the Kiggavik Project is expected to have minimal interaction with migratory and tundra wintering caribou herds. Qamanirjuaq collared caribou have been predominately located south of the RAA during the spring and fall migration periods. Beverly collared caribou have been predominately located west of the RAA during spring and fall migration. Wager Bay collared caribou occur mostly north and east of the RAA, and Lorillard collared caribou have occurred predominately east of the RAA during the spring and fall migration periods. Baker Lake collared caribou occur north and within the RAA during spring and fall migrations.

Collared caribou recorded within the RAA during the spring migration include twelve Baker Lake and one Lorillard caribou (Table 13.2-15). Collared caribou that were recorded travelling through the RAA during the fall migration period were five Baker Lake, one Beverly/Ahiak, two Qamanirjuaq and two Lorillard caribou (Table 13.2-15). Wager Bay collared caribou have never been recorded within the Kiggavik RAA during either migratory season. The number of collared migratory caribou from the Qamanirjuaq, Beverly and Ahiak herds crossing the RAA, where there is potential for caribou to interact with the Project, is low compared to the number of collared caribou in each of the herds. Only two of 78 (2.6%) collared Qamanirjuaq animals and one of 55 (1.8%) of the collared Qamanirjuaq and Beverly/Ahiak caribou have been recorded with the RAA during the fall migratory seasons. Of the tundra wintering caribou herds, the Baker Lake herd occurs the most within the RAA; twelve and five collared caribou have been recorded in the RAA during the spring and fall migration periods, respectively.

The tundra-wintering caribou herds cross the RAA during both migratory seasons, but the migratory caribou herds have only been observed crossing the RAA during fall migration. Most of the caribou occurrence in the RAA is during the fall migration. During fall migration, caribou are not as sensitive compared to other season for caribou (BQCMB 1999). Consequently, the magnitude of Project effects on caribou migration is relatively low.

Table 13.2-15 Count of the Number of Caribou Crossings of the RAA by Caribou Season and Herd

Season	Baker Lake		Ahiak and Beverly		Wager Bay		Qamanirjuaq		Lorillard	
	# x-ing RAA	Total caribou	# x-ing RAA	Total caribou	# x-ing RAA	Total caribou	# x-ing RAA	Total caribou	# x-ing RAA	Total caribou
Spring migration	12	40	0	61	0	20	0	112	1	20
Fall migration/rut	5	22	1	55	0	18	2	78	2	18

SOURCE:
Government of Nunavut and Government of Northwest Territories caribou collar data

13.2.3.5.1 Mine and North All-Season Road

After mitigation, residual effects of the Project on caribou movement include loss of potential migratory routes because of mine site infrastructure and potential avoidance of some water crossings. Caribou will be unable to move through some areas that were previously available (e.g., open pits, airstrips). The routing of the North All-Season Road is within 10 km of non-designated water crossings.

No collared caribou from the Qamanirjuaq, Beverly and Ahiak migratory herds have ever been observed within the Mine and North All-Season Road LAA (Table 13.2-16). Only caribou from the resident herds have been recorded crossing the LAA. Four Baker Lake caribou crossed the LAA during spring migration, and one Lorillard caribou crossed the LAA during fall migration. The footprint of the mine site and North All-Season Road does not overlap with the water crossings, and no protected water crossings are within 10 km of the Project footprint. However, four unprotected water crossings are within 10 km of the Project footprint (Table 13.2-17; Figure 13.2-19). Given the current distribution of all migratory caribou herds in the region, the magnitude of the effect of mine and road on causing changes to caribou migration is low.

Table 13.2-16 Number of Caribou Crossings of the Mine and North All-Season Road LAA by Caribou Herd and Season

Season	Baker Lake		Ahiak and Beverly		Wager Bay		Qamanirjuaq		Lorillard	
	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou
Spring migration	4	40	0	61	0	20	0	112	0	20
Fall migration/rut	0	22	0	55	0	18	0	78	1	18

SOURCE:
Government of Nunavut and Government of Northwest Territories caribou collar data.

Table 13.2-17 Summary of Caribou Water Crossings Known to Occur within 10 km of the Mine and North All-Season Road LAA

Water Crossing	Source	Protection	Distance to Project Footprint (km)
Long Lake (south end)	IQ study	None	7.8
Northwest of Baker Lake	IQ study	None	1.8
Thelon River	Baseline study	None	1.5
Thelon River west of Baker Lake	Baseline study	None	4.3

SOURCE:
Government of Nunavut and Government of Northwest Territories caribou collar data.

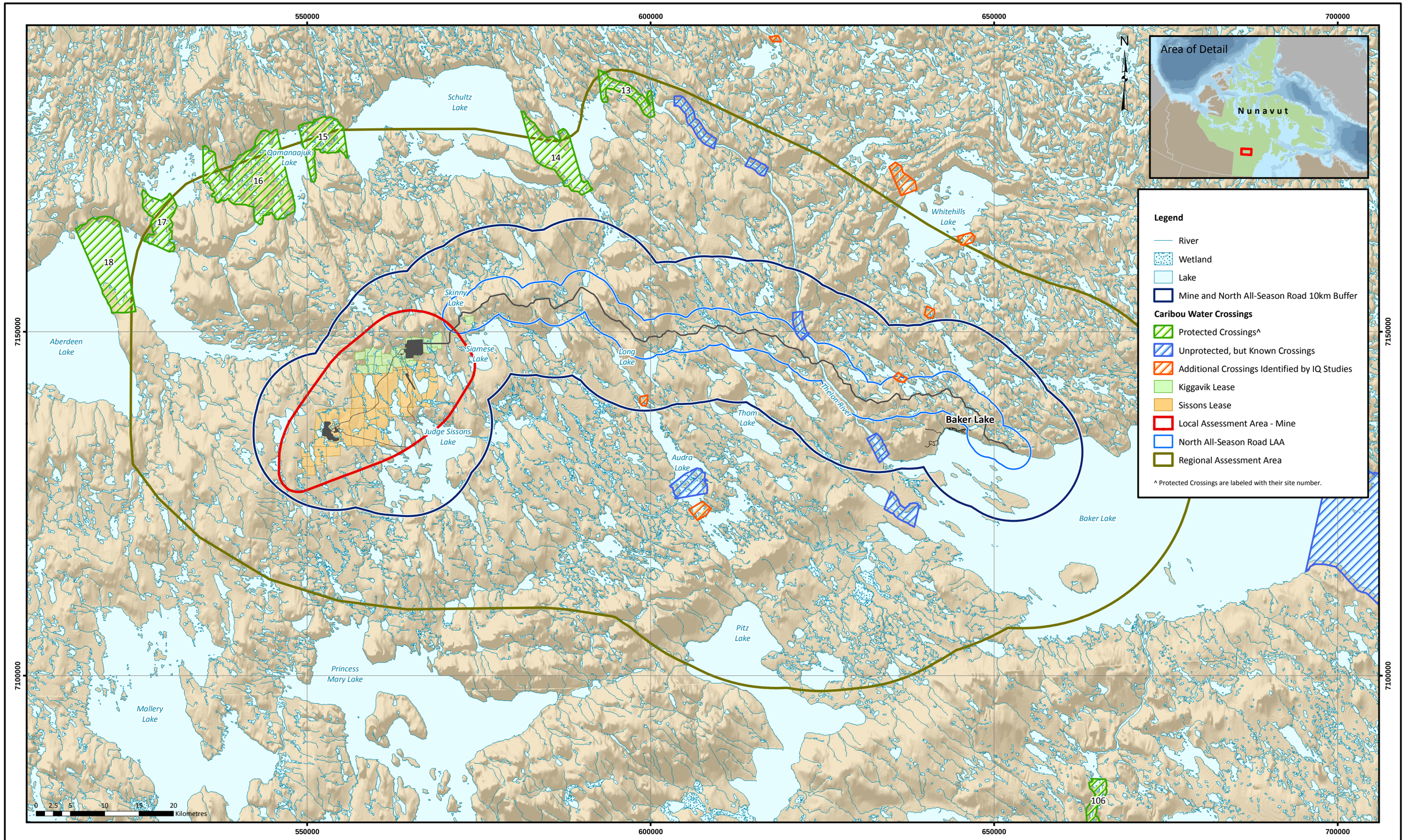
Residual effects of the mine are not anticipated to cause a detectable change in baseline caribou migrations. The limited number of caribou that migrate through the area and the Project mitigations should essentially eliminate Project effects on caribou migration. However, the regional caribou herds' use of space is more dynamic than previously thought (Nagy et al. 2011), consequently, how caribou migration and calving areas might change in the future cannot be predicted. This is a technical limitation of the assessment. The worst case scenario for the Kiggavik Project is a herd shifting its calving area so that the herd starts to migrate through the RAA. If this were to occur, caribou could experience some degree of restricted migration from the Project structures and activities. The magnitude of this effect would still likely be small because of applied mitigations, but there would be some type of diversion as caribou move across the LAA.

13.2.3.5.2 Mine and South Winter Road

After mitigation, residual effects of the Project on caribou movement across the mine and along the South Winter Road include loss of potential migratory routes because of mine site infrastructure and potential avoidance of some water crossings. Caribou will be unable to move through some areas that were previously available (e.g., open pits, airstrips). The routing of the South Winter Road option is within 10 km of non-designated water crossings.

No collared caribou from the Qamanirjuaq, Beverly and Ahiak migratory herds have ever been observed within the Mine and South Winter Road LAA (Table 13.2-18). Only caribou from the resident herds have been recorded crossing the LAA. Four Baker Lake caribou crossed the LAA during spring migration, and one Lorillard caribou crossed the LAA during fall migration. Five unprotected water crossings are within 10 km of the Project footprint. The footprint of the mine site and South Winter Road option overlaps with one unprotected water crossing, but no protected water crossings are within 10 km of the Project footprint (Table 13.2-19; Figure 13.2-20). The winter road will only be used from December to March, so use of the road will only overlap temporally with caribou migration during March. Temporary shutdowns when caribou are moving through the area will mitigate effects on caribou movement during migration.

Residual effects of the mine are not anticipated to cause a detectable change in baseline caribou migrations. The limited number of caribou that migrate through the area and the Project mitigations should essentially eliminate Project effects on caribou migration. However, while it is known that caribou herds are more dynamic (Nagy et al. 2011), how caribou migration and calving areas might change in the future cannot be predicted. This is a technical limitation of the assessment. The worst case scenario for the Kiggavik Project is a herd shifting its calving area so that the herd starts to migrate through the RAA. If this were to occur, caribou could experience some restricted migration from the Project structures and activities. The magnitude of this effect would still likely be small because of applied mitigations, but there would be some type of diversion as caribou move across the LAA.



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-19_Caribou_Water_Crossings_NAWAR.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., Dept. of Indian & Northern Affairs, Canadian Wildlife Service, Gebauer & Associates.*

FIGURE 13.2-19
CARIBOU WATER CROSSINGS WITHIN 10KM OF THE MINE AND NORTH ALL-SEASON ROAD

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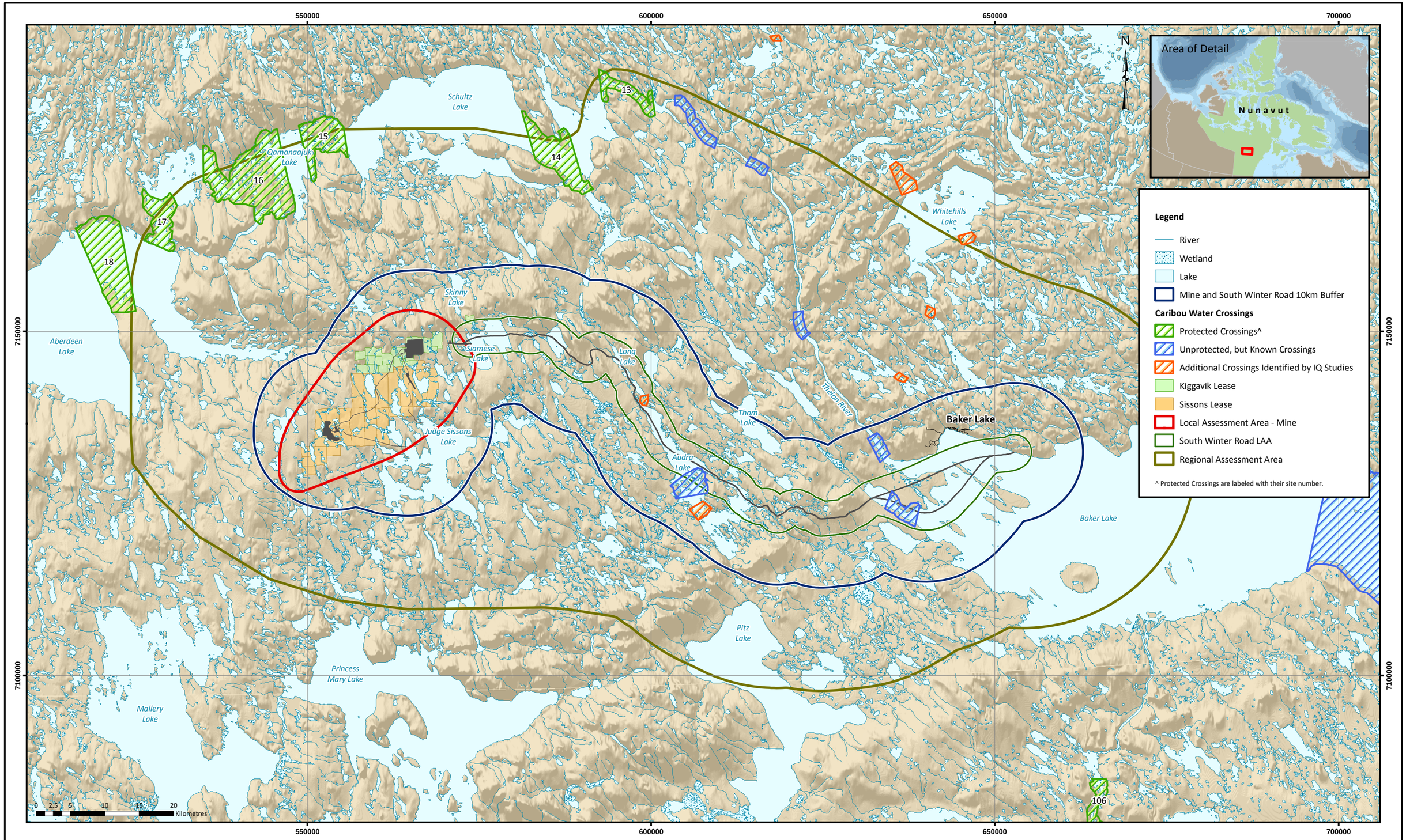

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-20_Caribou_Water_Crossings_S_Winter.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., Dept. of Indian & Northern Affairs, Canadian Wildlife Service, Gebauer & Associates.*

FIGURE 13.2-20
CARIBOU WATER CROSSINGS WITHIN 10KM OF THE MINE AND SOUTH WINTER ROAD

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Table 13.2-18 Number of Caribou Crossings of the Mine and South Winter Road LAA by Caribou Herd and Season

Season	Baker Lake		Ahiak and Beverly		Wager Bay		Qamanirjuaq		Lorillard	
	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou
Spring migration	4	40	0	61	0	20	0	112	0	20
Fall migration/rut	0	22	0	55	0	18	0	78	1	18
SOURCE: Government of Nunavut and Government of Northwest Territories caribou collar data.										

Table 13.2-19 Summary of Caribou Water Crossing Known to Occur within 10 Km of the Mine and South Winter Road LAA

Water Crossing	Source	Protection	Distance to Project Footprint (km)
Lake 25 km west of Baker Lake (on Audra Lake)	Baseline study	None	0.3
Thelon River west of Baker Lake	Baseline study	None	4.5
Baker Lake (southwest arm)	Baseline study	None	0.0
Long Lake (south end)	IQ study	None	0.3
Audra Lake	IQ study	None	4.0

13.2.3.5.3 Mine and North Winter Road

After mitigation, residual effects of the Project on caribou movement include loss of potential migratory routes because of mine site infrastructure and potential avoidance of some water crossings. Caribou will be unable to move through some areas that were previously available (e.g., open pits, airstrips). The routing of the South Winter Road option is within 10 km of non-designated water crossings.

No collared caribou from the Qamanirjuaq, Beverly and Ahiak migratory herds have ever been observed within the Mine and North Winter Road LAA (Table 13.2-20). Only caribou from the resident herds have been recorded crossing the LAA. Three Baker Lake caribou crossed the LAA during spring migration. During fall migration, one Lorillard and one Baker Lake caribou crossed the LAA. Seven unprotected water crossings are within 10 km of the Project footprint. The footprint of the mine site and North Winter Road option overlaps with one unprotected water crossing, but no protected water crossings are within 10 km of the Project footprint (Table 13.2-21; Figure 13.2-21). The North Winter Road will only be used during December to March, so use of the road will only overlap temporally with caribou migration during March. Temporary shutdowns when caribou are moving through the area will mitigate effects on caribou movement during migration.

Residual effects of the mine are not anticipated to cause a detectable change in baseline caribou migrations. The limited number of caribou that migrate through the area and the Project mitigations should essentially eliminate Project effects on caribou migration. However, while it is known that caribou herds are more dynamic (Nagy et al. 2011), how caribou migration and calving areas might change in the future cannot be predicted. This is a technical limitation of the assessment. The worst case scenario for the Kiggavik Project is a herd shifting its calving area so that the herd starts to migrate through the RAA. If this were to occur, caribou could experience restricted migration from the Project structures and activities. The magnitude of this effect would still likely be small because of applied mitigations, but there would be some type of diversion as caribou move across the LAA.

Table 13.2-20 Count of the Number of Caribou Crossings of the Mine and North Winter Road LAA by Caribou Herd and Season

	Baker Lake		Ahiak and Beverly		Wager Bay		Qamanirjuaq		Lorillard	
BQCMB Season	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou	# x-ing LAA	Total caribou
Spring migration	3	40	0	61	0	20	0	112	0	20
Fall migration/rut	1	22	0	55	0	18	0	78	1	18
SOURCE: Government of Nunavut and Government of Northwest Territories caribou collar data.										

Table 13.2-21 Summary of Caribou Water Crossing Known to Occur within 10 km of the Mine and North Winter Road LAA

Water Crossing	Source	Protection	Distance to Project Footprint (km)
Thelon River west of Baker Lake	Baseline study	None	8.6
Thelon River	Baseline study	None	4.0
Lake 25 km west of Baker Lake (on Audra Lake)	Baseline study	None	0.3
Long Lake (south end)	IQ study	None	0.3
Audra Lake	IQ study	None	4.1
Northwest of Baker Lake (town)	IQ study	None	0.0
Whitehills Lake (south end)	IQ study	None	8.7

550000 600000 650000 700000

7150000

7100000

N

Area of Detail

Nunavut

Schultz Lake

Qamanaajuk Lake

Whitehills Lake

Skinny Lake

Aberdeen Lake

Siamese Lake

Long Lake

Thom Lake

Thelon River

Baker Lake

Judge Sissons Lake

Audra Lake

Pitz Lake

Princess Mary Lake

Mallery Lake

13 14 15 16 17 18 106

Legend

- River
- Wetland
- Lake
- Mine and North Winter Road 10km Buffer

Caribou Water Crossings

- Protected Crossings^
- Unprotected, but Known Crossings
- Additional Crossings Identified by IQ Studies
- Kiggavik Lease
- Sissons Lease
- Local Assessment Area - Mine
- North Winter Road LAA
- Regional Assessment Area

^ Protected Crossings are labeled with their site number.

0 2.5 5 10 15 20 Kilometres

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.2-21_Caribou_Water_Crossings_N_Winter.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., Dept. of Indian & Northern Affairs, Canadian Wildlife Service, Gebauer & Associates.*

FIGURE 13.2-21
CARIBOU WATER CROSSINGS WITHIN 10KM OF THE MINE AND NORTH WINTER ROAD

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

13.2.3.6 Determination of Significance for Change in Movement

The effect of the Project on caribou migration because of Project infrastructure and activities is assessed as not significant. Seasonal shutdowns of various Project activities are possible when large numbers of caribou are observed approaching the site, and that mitigation should be appropriate to allow free movement through the RAA. Confidence in the prediction is moderate over the short-term because variability in caribou movement is not entirely understood. The dynamic nature of caribou herd range use means that caribou migration over the life of the Project cannot be predicted.

13.2.3.7 Summary of Project Residual Environmental Effects for Change in Movement

Table 13.2-22 summarizes the residual environmental effects of the Project on change in movement of caribou and muskox.

13.2.3.8 Compliance and Environmental Monitoring for Change in Movement

AREVA will conduct the following monitoring for change in movement of caribou and muskox:

- make contributions to a government-led caribou collaring program
- monitor caribou use of water crossing that are within 10 km of the Project activities
- collar updates being provided from governments to warn of approaching caribou so that a greater level of vigilance for caribou can be observed. That information will be used to advise temporary shutdown of traffic on roads or other activities as appropriate.

Table 13.2-22 Summary of Project Residual Environmental Effects for Change in Movement

Project Phase	Mitigation / Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in Caribou and Muskox Movement — North All-Season Road Option												
Construction, Operation, Final Closure	Temporary road closures, road design, snow management	N	L	L	MT	C	R	U	N	N/A	M	Continued monitoring (collar studies) of migratory and Baker Lake herds
Change in Caribou and Muskox Movement — Winter Road Options												
Construction, Operation, Final Closure	Temporary road closures	N	L	L	ST	R	R	U	N	N/A	M	Continued monitoring (collar studies) of migratory and Baker Lake herds

Table 13.2-22 Summary of Project Residual Environmental Effects for Change in Movement (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible: No anticipated effect on wildlife species

L Low: Observable effect on wildlife species but not likely to affect the species' sustainability in the Project area

M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the region

H High: Measurable effect on wildlife species but that will likely affect the species' sustainability in the region

Geographic Extent:

S Site-specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities

13.2.4 Assessment of Change in Health – Caribou and Muskox

As a result of emissions from the Project to the atmosphere and water, there is the potential for caribou and muskox to be exposed to COPC. The potential for these emissions to cause adverse effects in the populations of caribou and muskox is evaluated.

13.2.4.1 Analytical Methods for Change in Health

Emissions from the Project can affect the concentrations of COPC in the environment (e.g., water, soil, vegetation), which in turn will affect the exposure of caribou and muskox as they consume these items. The COPC included in the assessment include uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, and zinc.

Caribou consume ground and tree lichens in the winter, augmented by fresh green vegetation in the spring. Muskox feed extensively on willows, grasses, and sedges. To estimate the exposure of caribou and muskox, it is necessary to estimate the concentration in all environmental components that will be consumed (e.g., lichen, browse). Detailed air quality modelling (Tier 2, Volume 4) and water quality modelling (Tier 2, Volume 5) are used as inputs to the environmental pathways assessment. The concentrations in environmental components (e.g., vegetation) are predicted by using transfer factors that relate the concentration in different components (e.g., soil-to-plant). The transfer factors are based on site-specific information where possible, augmented by literature data. Of particular interest for the exposure to caribou is lichen. This vegetation can accumulate COPC from the air due to deposition and nutrient uptake, and since they have a long life, the concentration can increase over time.

The intake of COPC is estimated using the predicted concentrations and assumptions about how much the caribou and muskox consume. The amount of time that the wildlife spend in the area is also an important factor. For caribou, it is assumed some caribou may spend 2% of their time in the LAA while other caribou may spend 4% of their time in the RAA. These are cautious estimates that are based on telemetry data from the caribou herd. For muskox, it is assumed they would be present for 10% of their time in the area of Judge Sissons Lake. The estimated intakes are compared to benchmarks that are protective of mammals. For estimating radionuclide dose, the concentration of each radionuclide within the animal is estimated from the calculated intake by using a transfer factor. Dose coefficients are used to estimate the dose from each radionuclide, based on the concentration. Radiation effects on biota depend not only on the absorbed dose, but also on the relative biological effectiveness (RBE) of the particular radiation (i.e., alpha, beta or gamma radiation). Recent recommendations have focused on an RBE of 10 for alpha radiation; however, to illustrate the effects of uncertainty in RBE, a range is used. The total dose, which is based on the baseline plus Project emissions for the sum of the uranium-series radionuclides, is compared to a benchmark that is protective of mammals (1 mGy/d).

The scenario carried through the ecological assessment is based on separate discharges from the Kiggavik water treatment plant (WTP) and Sissons WTP, an extended operating period (25 years) followed by a 22-year period of consolidation where water treatment would be required. The assessment accounted for the uncertainty and variability in the emissions and the behaviour in the environment. The details are provided in the Ecological Risk and Human Health Risk Assessment (Tier 3, Appendix 8A).

13.2.4.2 Baseline Conditions for Change in Health

Under baseline conditions, caribou and muskox are exposed to COPC because these constituents are present naturally in the environment. Concentrations of COPC in caribou tissue are measured as a component of the Ecological Risk Assessment. This baseline information is presented in Tier 3, Appendix 8A and summarized in Tables 13.2-23 and 13.2-24.

Table 13.2-23 Screening Index Values for Caribou

COPC	Screening Index (SI)		
	Baseline	Caribou Present in the LAA	Caribou Present in the RAA
Arsenic	<0.001	<0.001	<0.001
Cadmium	0.008	0.009	0.008
Cobalt	<0.001	<0.001	<0.001
Copper	0.088	0.088	0.088
Lead	0.002	0.002	0.002
Molybdenum	0.003	0.003	0.003
Nickel	0.006	0.006	0.006
Selenium	0.033	0.033	0.033
Uranium	<0.001	0.004	0.002
Zinc	0.029	0.029	0.029
Radioactivity	0.07	0.07	0.07

NOTES:
SI values for non-radiological COPC are based on the maximum mean exposure compared to a LOAEL
SI values of radiological effects include the contribution from U-238, Th-230, Ra-226, Pb-210 and Po-210, using an RBE of 40 and compared to a benchmark of 1 mGy/d
Details of calculation as well as additional results are provided in Tier 3, Appendix 8A

Table 13.2-24 Screening Index Values for Muskox

COPC	Screening Index (SI)	
	Baseline	Muskox Present in the LAA at Judge Sisson Lake
Arsenic	0.001	0.001
Cadmium	0.032	0.032
Cobalt	0.002	0.002
Copper	0.334	0.334
Lead	0.002	0.002
Molybdenum	0.012	0.012
Nickel	0.013	0.013
Selenium	0.008	0.008
Uranium	<0.001	<0.001
Zinc	0.155	0.155
Radioactivity	0.02	0.02

NOTES:
SI values for non-radiological COPC are based on the maximum mean exposure compared to a LOAEL
SI values of radiological effects include the contribution from U-238, Th-230, Ra-226, Pb-210 and Po-210, using an RBE of 40 and compared to a benchmark of 1 mGy/d
Details of calculation as well as additional results are provided in Tier 3, Appendix 8A

13.2.4.3 Effect Mechanisms and Linkages for Change in Health

The assessment of changes in health of caribou and muskox depends on the estimated changes in concentrations of environmental components such as vegetation and soil, which are derived from the atmospheric and aquatic environment assessments.

The Project-environment interactions and effects described in the Atmospheric Environment (Tier 2, Volume 4) and Aquatic Environment (Tier 2, Volume 5) form the basis for the effects mechanisms and linkages. The Project air quality effects relate to emissions of air COPC from open pit and underground mining and supporting activities, milling and vehicle traffic on unpaved roads. The Project water quality effects relate to emissions of COPC from WTPs at the Kiggavik and Sissons mine sites. Complete details about the COPC sources and all assumptions used in the assessments are provided in the atmospheric and aquatic environment assessments.

13.2.4.4 Mitigation Measures and Project Design for Change in Health

Design aspects, operational measures and other mitigation measures have been incorporated into the current Project design, which will reduce Project-associated emissions and/or the potential effect of Project-related emissions.

The Atmospheric Environment report (Tier 2, Volume 4) provides a detailed list of the mitigation measures applied to reduce the changes to ambient air quality. The following mitigation measures have been incorporated to reduce emissions of dust containing COPC:

- minimizing or reducing vehicle speed on unpaved mine site roads (including pit ramps) and the Kiggavik-Sissons access road and enforce speed limits, where possible
- applying water or another approved dust suppressant to the surfaces of unpaved mine site roads (including pit ramps) and the Kiggavik-Sissons access road, when possible
- maintaining all unpaved road surfaces via grading or other maintenance practices to minimize the amount of silt (i.e., fine particles) present in the roadbed material
- installing appropriate air pollution controls on the exhaust stacks of the mill complex and acid plant (e.g., wet scrubbers, dust collectors) and
- releasing tailings to the TMFs as a slurry below a water surface to avoid tailings dust emissions

The Kiggavik WTP and Sissons WTP have been designed so that the effluent will meet all appropriate regulations such as the Metal Mining Effluent Regulation (MMER) as well as site-specific discharge limits. Environmental considerations were paramount in the selection of the appropriate technology for the WTP. Further detail on the design of the WTP can be found in Volume 2.

13.2.4.5 Residual Effects for Change in Health

In this study, adverse effects from exposure to COPC are characterized by a screening index, which is calculated by dividing the predicted exposure by the toxicity reference value for each ecological receptor as follows:

$$Screening\ Index = \frac{Exposure}{Toxicity\ Reference\ Value}$$

For the wildlife species, the US EPA risk-based ecological soil screening levels (Eco-SSLs) (US EPA 2010) are used as the primary data source for the derivation of toxicity reference values used to determine the potential for an effect. For this assessment, the lowest observable adverse effect levels (LOAELs), based on growth and reproduction, are selected because these endpoints are considered to be the most relevant for the maintenance and persistence of wildlife populations. For COPC without Eco-SSL data (in this case uranium), literature studies were reviewed and values from long-term (chronic) exposure studies were selected. The Eco-SSL database provides information for a number of different species that could be used as a surrogate for other species with similar diets. For example, for molybdenum, the benchmark

value for a calf is used as the surrogate for caribou. If none of the test species were similar to the ecological receptors selected in this assessment, then the lowest value is selected as the conservative default benchmark for the ecological receptor. The Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A) provides the final selected values, along with additional detail on the derivation and rationale for the value.

Screening index values are not estimates of the probability of ecological effect. Rather, the index values are correlated with the potential of an effect (i.e., higher index values imply a greater potential of an effect). The estimated exposure of caribou and muskox includes both the natural baseline levels as well as the effect of the Project emissions. Therefore, a screening index value less than 1.0 indicates that the estimated total exposure is less than the threshold that is associated with a potential adverse effect. The screening index values are shown in Table 13.2-23 for caribou and Table 13.2-24 for muskox.

With the potential exception of cadmium and uranium exposure to caribou, it is not expected that the emissions from the Project will result in a discernible change in exposure to COPC. The results show that it is not expected that the exposure to caribou or muskox will exceed exposure levels associated with adverse effects.

13.2.4.6 Determination of Significance for Change in Health

The level of exposure for caribou and muskox to most COPC are not expected to change from baseline and the exposure will remain below exposure levels associated with adverse effects. No residual effects are expected on the health of caribou and muskox as a result of exposure to COPC.

13.2.4.7 Compliance and Environmental Monitoring for Change in Health

No specific monitoring requirements are recommended, based on the assessment for change in health of caribou and muskox. The monitoring of other environmental components (e.g., water, lichen) will provide information for confirming the results of this assessment.

13.3 CUMULATIVE EFFECTS ANALYSIS FOR CARIBOU AND MUSKOX

The conditions described in the Base Case are a result of the effects of past and current projects on wildlife and habitat. The assessment of the Project Case describes the cumulative effects of the Project on the Base Case. This section addresses how environmental effects associated with reasonably foreseeable future projects and human activities will interact with the Project Case.

Although the Kiggavik Project will not have a measurable or reasonably-expected adverse effect on mortality risk, there are many causes of caribou mortality. The predominant cause of cumulate mortality related to potential Project effects is the potential for increased cumulative harvest mortality. Caribou are harvested by several communities throughout their range. The potential for increased harvest as a result of increased harvester access on the North All-Season Road could interact cumulatively with other harvest pressures on the Qamanirjuaq caribou herd.

Caribou harvest is not subject to a Total Allowable Harvest (TAH) (i.e., there is no quota for subsistence harvesters). Based on the contradictory data on current caribou population levels and harvest rates (see Section 13.3.2), the determination of whether Baker Lake harvesters are capable of harvesting more caribou than sustainable limits suggest is difficult to determine.

Effects of climate change on caribou populations are unknown, but will probably be realized in its effects on forage renewal and energy expenditure. Effects will be largely undetectable within the 20 to 30 year life of the mine. The effect of increased harvester access on the North All-Season Road could interact cumulatively with other climate-driven pressures on the Qamanirjuaq caribou herd, which might result in an unsustainable mortality rate.

Project construction and operation activities will contribute to direct and indirect mortality risk, habitat loss, effects on movement, and health. These effects have the potential to act cumulatively in part of the range of the caribou and muskox that could interact with the Project. The development of the mine, port access, and road access has the potential to increase similar development activity-related disturbances and resulting effects on terrestrial wildlife and habitat.

13.3.1 Screening for Cumulative Environmental Effects

Residual effects of increased mortality risk and habitat loss/reduced suitability are expected because an all-season road can provide additional hunter access over several generations of caribou, and habitat will be lost in the long-term to the footprint of the Project. Because these effects will be similar to other current and future terrestrial development activities within the range of caribou and muskox that could interact with the Project, and will overlap in time and space, these cumulative effects are assessed.

Residual effects on movement and health are not expected to be detectable and are therefore not considered in this cumulative effects assessment.

13.3.2 Assessment of the Cumulative Effects: Change in Mortality

Increased hunter harvest of caribou can cumulatively increase due to the indirect effect of providing increased hunter access to the landbase. Muskox mortality from harvest within the Kivalliq region is not expected to exceed sustainable harvest levels because muskox harvest is currently managed through hunting quotas by the GN. Muskox can only be harvested with a tag

acquired from the NWMB. The muskox harvest quotas in the Kivalliq region are based on 1991 survey information; however, more recent surveys suggest the muskox population has grown. The number of tags issued is likely below the population's sustainable harvest level (Government of Nunavut 2007).

13.3.2.1 Effect Mechanisms and Linkages for Cumulative Change in Mortality

The Project will increase mortality risk primarily to the Qamanirjuaq caribou when they are present in the RAA during summer movement. Baker Lake hunters already harvest animals from the Qamanirjuaq herd (the BQCMB apportions the Baker Lake caribou harvest as 40% Qamanirjuaq, 20% Beverly and 40% Wager Bay; BQCMB 2008). Mortality risk during winter on the Resident herd(s) is not expected to increase because hunters are access their traditional hunting areas by snow machine, independent of road access.

It is unclear whether the increase in mortality risk is due to: 1) an increase in proportion of total harvest from Qamanirjuaq animals or 2) an overall increase in the total number of caribou harvested by Baker Lake hunters. It is difficult to determine if total harvest has or has not increased in Baker Lake because statistics were collected in the early 1970s. However, the harvest may increase to meet the demands of an increasing human population in Baker Lake. Hunters will continue to harvest in the Baker Lake region, including use of the Kiggavik road and other roads when caribou are known to be present.

Several other factors considered in the cumulative mortality risk include:

- Traditional hunting patterns could shift (i.e., affect different herds at different times of the year) and the number of animals taken from different herds vary. Hunting patterns could change for subsistence, licensed, sport, and commercial harvesters, based on road access to areas where caribou might be present.
- The total caribou harvest is likely to remain at current levels or increase across the range of the caribou herds as the human population increases. This total harvest will be independent of the Kiggavik Project's North All-Season Road, but the road may facilitate an increase in harvest of Qamanirjuaq caribou.
- Total foreseeable mortality risk (per year) from all causes is unknown for the herds that interact with the Project. Harvest estimates are available only for the Beverly and Qamanirjuaq herds across their range.
- The Project could either increase the total harvest among all herds, or increase the proportion of animals taken from particular herds (most likely the Qamanirjuaq). The effect of harvest could be either a) a change in distribution of harvest pattern, which is unlikely to have a cumulative effect or b) increase total harvest which will have a cumulative effect across the caribou populations.

- Other Project contributions to harvest include effects of the Meadowbank Project's access road which may facilitate access to Resident, Lorillard, Wager Bay and Beverly/Ahiak herds during the snow-free season.
- The largest and most important influence on long-term population trends are forage and range (Government of Nunavut 2005).
- Effects of climate change on caribou populations are unknown, but will probably be realized in its effects on forage renewal. Effects will likely not be detectable within the 20- to 30-year life of the mine.

There is no information on natural mortality factors such as predation, disease, and other causes of natural death. How rates of natural mortality changes through time is unknown. Climate change may exacerbate these effects, but predictive capability is low. Climate change will factor into the cumulative changes in mortality, likely by indirectly causing population-wide declines in body condition.

13.3.2.2 Analytical Methods for Change in Mortality

The effects of cumulative harvest-related mortality are analyzed by reviewing harvest patterns and caribou population trends near the community of Baker Lake. Increased mortality risk is quantified by determining the caribou herds that would most likely be exposed to Project activities (direct effect) and hunter harvest west of the Thelon River during the snow-free season.

The following information is used for determining the increased mortality risk to caribou and level of significance:

- population status and trends for caribou herds that are known to interact with the Project
- current harvest levels and harvest trends on the various caribou herds by Baker Lake hunters and harvest statistics for all herds known to interact with the Project across their range
- identification of harvest thresholds (e.g., TAH or some other predetermined sustainable harvest limit) and the potential for the Project to facilitate overharvest

Analysis for a potential increase in mortality risk focuses on the potential for an increase in human harvest of caribou. The status and trends of the caribou herds known to use the area within the RAA are reviewed. Hunter harvest data (traditional, recreational and commercial recreational) are quantified and included in the analysis. (Natural mortality statistics were not available for any of the herds in the RAA.) Predicted future harvest related mortality is compared to identified harvest thresholds.

The following assumptions are made to assist the prediction effects on individual herds:

1. Harvesters will use the area if access is improved.
2. A harvest rate of 3.75% of the estimated herd size is considered a sustainable harvest (derived from Campbell et al. 2010, expressed as 5% of 75% [i.e., the standing stock] of the caribou population).
3. Baker Lake residents are regularly able to meet their caribou harvest needs each year (e.g., if a family needs 10 caribou, they are likely to get 10 caribou).
4. Baker Lake harvest is mostly for subsistence purposes, so the dietary needs/wants of the community will place a limit on caribou harvested. The current annual total harvest estimates of caribou by the community of Baker Lake ranges between 2,000 (BQCMB 2006) and 6,000 caribou (Baker Lake HHS; see Tier 3, Appendix 6C).
5. In the Baker Lake region, roads provide little advantage to harvest access in winter because snowmobiles are more versatile and are better able to travel across the landscape.
6. Collar locations represent herd range use and locations are representative of the spatial distribution of the caribou herd. For example, if three of 100 collared animals occurred in an area during some time period, then it is assumed that 3% of the herd would be present in that area.
7. Beverly/Ahiak, Lorillard, Qamanirjuaq, Wager Bay and Resident caribou herds are available for harvest throughout the RAA, though at different times of the year.
8. The detection of caribou by hunters, and therefore mortality risk, is increased within 10 km of a road (a reasonable maximum sight distance from a high point of ground); beyond 10 km the risk is indistinguishable from baseline conditions.

The North All-Season Road is the focus of the mortality risk assessment on caribou because it is the only option that provides hunters access to a previously inaccessible area during the snow-free season. The winter access road options are anticipated to provide little improvement to winter harvest access.

13.3.2.3 Baseline Conditions for Change in Mortality

To determine the Project's potential for increased risk of caribou mortality, an understanding of the following is necessary: 1) abundance and distribution of caribou herds that can be found within the RAA; 2) current harvest patterns and potential future patterns following infrastructure development; and 3) biologically permissible harvest levels that will not affect sustainability of herd population levels.

While caribou distribution and population association is discussed at length in the baseline report (Tier 3, Appendix 6C), this assessment focuses on a summary of knowledge on seasonal abundance of caribou of known populations in the RAA and identification of thresholds of harvest mortality where they are identified or a reasonable estimate can be made.

13.3.2.3.1 CARIBOU DISTRIBUTION AND POPULATION TRENDS

The interchange of individuals among herds was observed from satellite-collaring data. Specific information on each of the caribou herds near the Kiggavik RAA is briefly described below; a more complete summary is available in the wildlife baseline report (Tier 3, Appendix 6C). In many cases, the current population status of these herds is unknown, difficult to accurately determine, or is currently being reassessed.

The ranges of the Beverly, Qamanirjuaq, Lorillard, Wager Bay, Ahiak and the Baker Lake resident herds overlap with the RAA. For the purposes of TAH recommendations, the GN recognizes five barren ground caribou populations that overlap with the Project's RAA: BC/01 (Beverly); BC/02 (Qamanirjuaq); BC/03 (Lorillard); BC/04 (Wager) and BC/07 (Ahiak) (Government of Nunavut 2005). Recent analysis has shown that the Beverly, Ahiak and Qamanirjuaq are migratory caribou moving between calving grounds and wintering grounds in or near the tree line. They are distinct from northeastern mainland animals (i.e., those wintering on tundra: Lorillard, Wager Bay and Resident caribou).

Beverly Herd — The historic Beverly herd range extends over 1,000 km from boreal forests in northern Saskatchewan and Manitoba (i.e., Clearwater River and Reindeer Lake areas), across the subarctic taiga of Northwest Territories, to the tundra of west-central Nunavut (i.e., Pelly and Garry lakes area). The herd range has traditionally overlapped with the Bathurst and Ahiak caribou in the west, and the Qamanirjuaq caribou in the east. The western and eastern limits are much less defined, extending a minimum of 600 km from Great Slave Lake and Great Bear Lake in the Northwest Territories, east of Dubawnt Lake, Nunavut. The Beverly herd appears to have moved to a different calving area and current population estimates are not available.

In the 1980s and 1990s, the population was estimated to be 250,000 animals. There were no population surveys from 1995 to 2007. A 2008 survey spotted only 93 breeding cows during the reconnaissance survey of the Beverly calving ground, suggesting either a major population decline or a change in calving ground location. Some experts suggest that Beverly caribou previously calving in the traditional calving grounds have migrated further north to the Queen Maud Gulf to calve, possibly amalgamating with the Ahiak herd animals.

Ahiak Herd — The Ahiak herd range extends from the Queen Maud Gulf to south of the Thelon Game Sanctuary, and west to the Great Slave Lake. In the southern part of their winter range, below the tree line, the Ahiak herd may overlap with wintering Beverly caribou. Recent data (to 2010) show that collared cows from the Beverly and Ahiak herds appeared to remain north of the Thelon River and west of Aberdeen Lake, with a general southwestward trend in movement outside of the RAA.

The population status of the Ahiak herd is unknown, but a mid-1990s overview estimated the herd at approximately 200,000 caribou. Considerable uncertainty currently exists regarding the status of the Beverly and Ahiak herds. Some experts suggest that the Beverly and Ahiak animals may be part of a larger population with two distinct previous calving locations.

Qamanirjuaq Herd — The east-west range extends approximately 500 km, from the shores of Hudson Bay to the southern Kivillaq region to Aberdeen Lake. The north-south range extends approximately 1,000 km from the Thelon River and Baker Lake, Nunavut to south of Brochet, Manitoba. In 2009 and 2010, the only collared animals known to be present during post-calving season in the Kiggavik RAA were from the Qamanirjuaq herd.

Government of Northwest Terrorities surveys in the 1970s documented fewer than 50,000 animals. But, in the 1980s, the herd increased to approximately 250,000 animals, peaking in 1994 at 496,000 animals. Thereafter, the population declined to approximately 350,000 animals in 2008. The decline appears to have continued since then, but recent population data are not available.

A GN-coordinated Beverly/Ahiak/Qamaniruaq population survey was conducted in summer 2011 and results are pending.

Lorillard and Wager Bay (Northeastern Mainland) Herds — These herds are less well understood than the three described previously. Satellite collar location data shows that the annual range of collared females extends from the northeast mainland Kivalliq to north and west of Baker Lake during the winter. With the exception of one or two collared animals, collared cows from the Lorillard and Wager Bay herds have remained north of the Thelon River in all seasons. There are no published population estimates or trends.

Resident (Northeastern Mainland) Herd — The range of this herd is undefined, but satellite collar data show these animals to be regularly found near the Kiggavik RAA, primarily during the winter. Collar data from the calving period identified areas east of the traditional Ahiak calving grounds, in the Chantrey Inlet area (between Chantrey Inlet and Pelly Bay) and north into Boothia Peninsula. There are no published population estimates or trends.

The largest number of caribou observed in the RAA to date was a group of an estimated 10,000 individuals, with a large proportion of cows and calves, recorded on July 25, 2010, approximately 14 km northwest of the Kiggavik camp. Several small groups of cows, calves and bulls were observed and monitored (from the ground) over a two to three week period in 2010. Other large groups were observed during late July/early August 2009, including a group of 405 caribou of predominately bulls (93%) spotted on July 15, 2009 north of Thom Lake. A group of 2,000 caribou of predominately cows (52%) and calves (33%) was observed south of the Sissons Lease and northwest of Buzzard Lake on July 29, 2009 and another group of 3,000 caribou composed of 65% bulls, 30% cows, and 5% calves was observed southeast of Buzzard

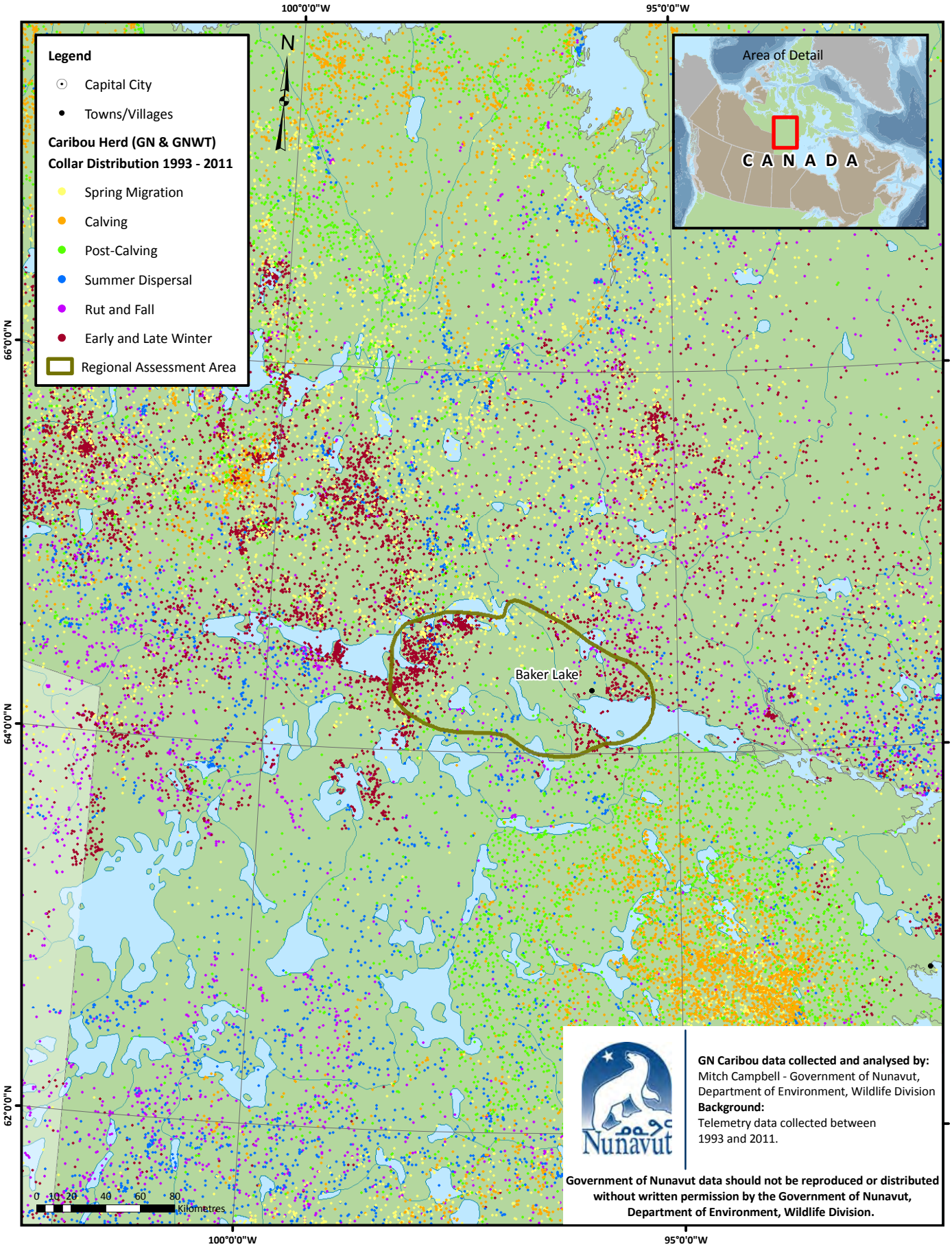
Lake in August 2009. Satellite collar data for 2009 and 2010 suggest that these animals were associated with the Qamanirjuaq herd.

Across most of the Kivalliq region where caribou collar data are available, the RAA generally has a relatively sparse distribution of collar locations relative to all collar locations by season (Figure 13.3-1). Based on a review of all available information that includes collars, observations, and IQ, animals from all regional herds can be found within the RAA during the winter and snow-free seasons. Collar locations are distributed sporadically within the RAA. The caribou herds most likely to interact with the Project during the summer is the Qamanirjuaq herd (Figure 13.3-2) and the Resident herd during the winter (Figure 13.3-3). Collar locations show the Qamanirjuaq herd is known to occur along the southern portions of the RAA (Figure 13.3-1) during the summer, while individuals from the Resident herd occur in the northwest portion of the RAA during the winter. The abundance of collar locations for this herd may be due in part to animals being initially collared in this area. Capture effects that could potentially cause a change in animal behaviour that resulted in a longer residency period in this area are unknown. Table 13.2-1 summarizes the proportion of satellite collar locations for each herd in relation to the RAA.

Beverly and Ahiak caribou are unlikely to interact with the Kiggavik Project outside of the winter seasons. Collared caribou representative of the Beverly and Ahiak herds have only been located in the eastern portion of the RAA around Baker Lake (Figure 13.3-3). Wager Bay caribou predominantly occur north of the Thelon River and Baker Lake.

Most of the harvest pressure comes from harvesters travelling on the Thelon River or travelling north from Baker Lake. The proposed North All-Season Road is unlikely to increase harvest related mortality risk to Wager Bay caribou because these caribou occur relatively infrequently within 10 km of the proposed road (Table 13.2-1). Resident caribou occur within the RAA mostly during the winter period, and their occurrence has mostly been north and west of the proposed mine site (see Figure 13.3-3). Qamanirjuaq caribou occur within the RAA primarily during July and August, with most collar locations occurring south of the proposed North All-Season Road.

Three, twelve and five caribou collar locations from Wager Bay, Qamanirjuaq and Resident herds, respectively, were recorded within 10 km of the proposed North All-Season Road during the snow-free season (Table 13.3-1). These numbers correspond to 0.2% of the Wager Bay, less than 0.1% of the Qamanirjuaq and approximately 0.1% of the Resident caribou collar location data for the snow-free period. Assuming collar locations are representative of the herd's range use and proportional to the number of animals from a herd occurring in an area, a low proportion of caribou from each of these herds are likely to be exposed to increased mortality risk from human harvest. A description of caribou presence in the RAA and adjacent areas by season is presented in Table 13.3-2.



Projection: NAD 1983 UTM Zone 14N
Creator: Caslys Consulting Ltd.
Date: 04/10/2012 Scale: 1:3,000,000
File: 13.3-1_Seasonal_Herd_Presence_RAA.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, Geological Survey of Canada, BQCMB, and Caslys Consulting Ltd.*

FIGURE 13.3-1
SEASONAL CARIBOU PRESENCE IN THE REGION

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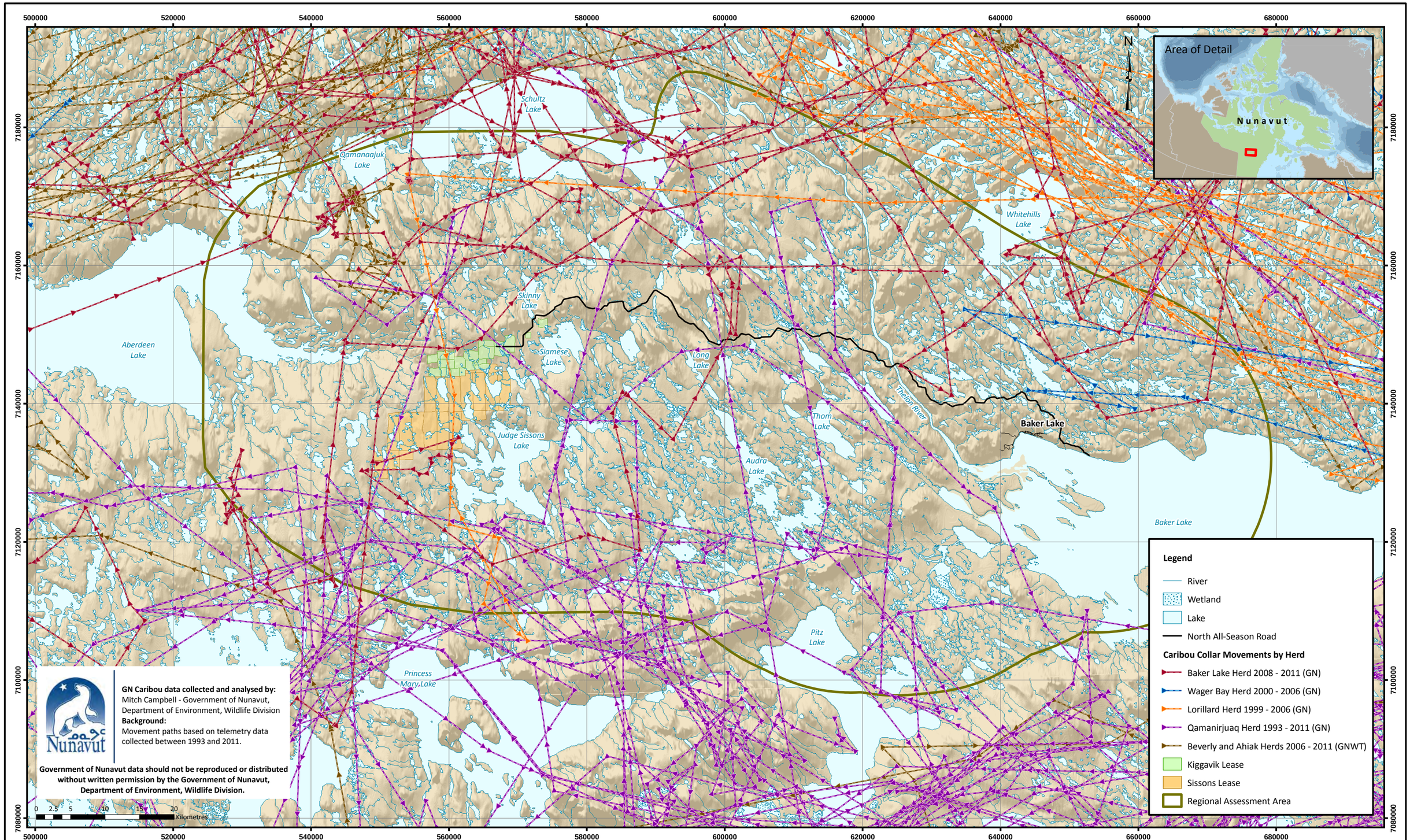
Table 13.3-1 Caribou Proximity to the RAA and the North All-Season Road by Herd and Season

Caribou Seasons	Number and Proportion of Collar Locations relative to the RAA																			
	'Resident'[a]				Lorillard[b]				Qamanirjuaq[c]				Wager Bay[d]				Beverly/Ahiak[e]			
	No. points	<2 km	<10 km	RAA	No. points	<2 km	<10 km	RAA	No. points	<2 km	<10 km	RAA	No. points	<2 km	<10 km	RAA	No. points	< 2km	<10 km	RAA
Early Winter	1810	0	10	468	621	1	7	36	4942	1	9	33	536	0	0	4	8790	1	4	53
(Nov. 1–Dec. 31)		0.0%	0.6%	25.9%		0.2%	1.1%	5.8%		0.0%	0.2%	0.7%		0.0%	0.0%	0.7%		0.0%	0.0%	0.6%
Late Winter	1986	0	0	95	676	0	0	17	5498	0	10	27	599	0	0	3	11240	3	51	63
(Jan. 1–Mar. 15)		0.0%	0.0%	4.8%		0.0%	0.0%	2.5%		0.0%	0.2%	0.5%		0.0%	0.0%	0.5%		0.0%	0.5%	0.6%
Spring Migration	1860	2	11	81	793	0	0	1	6255	0	0	0	640	0	0	0	14831	0	0	0
(Mar. 16–May 25)		0.1%	0.6%	4.4%		0.0%	0.0%	0.1%		0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		0.0%	0.0%	0.0%
Total Winter Season	5656	2	21	644	2090	1	7	54	16695	1	19	60	1775	0	0	7	34861	4	55	116
(Nov. 1–May 25)		0.0%	0.4%	11.4%		0.0%	0.3%	2.6%		0.0%	0.1%	0.4%		0.0%	0.0%	0.4%		0.0%	0.2%	0.3%
Calving	846	0	0	0	367	0	0	0	3399	0	1	4	302	0	0	0	6536	0	0	0
(May 26–Jun 25)		0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		0.0%	0.0%	0.1%		0.0%	0.0%	0.0%		0.0%	0.0%	0.0%
Post-calving	977	0	0	0	406	0	0	0	3626	2	8	64	325	0	0	0	6055	0	0	0
(Jun 26–Jul 31)		0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		0.1%	0.2%	1.8%		0.0%	0.0%	0.0%		0.0%	0.0%	0.0%
Late Summer	1206	0	0	0	505	0	0	1	4077	0	3	29	430	1	3	4	7156	0	0	0
(Aug 1–Sep. 15)		0.0%	0.0%	0.0%		0.0%	0.0%	0.2%		0.0%	0.1%	0.7%		0.2%	0.7%	0.9%		0.0%	0.0%	0.0%
Fall	1042	2	5	42	510	0	0	7	4025	0	0	7	430	0	0	0	6235	0	0	1
(Sep. 16–Oct. 31)		0.2%	0.5%	4.0%		0.0%	0.0%	1.4%		0.0%	0.0%	0.2%		0.0%	0.0%	0.0%		0.0%	0.0%	0.0%
Total Snow-free Season	4071	2	5	42	1788	0	0	8	15127	2	12	104	1487	1	3	4	25982	0	0	1
(May 26–Oct. 31)		0.0%	0.1%	1.0%		0.0%	0.0%	0.4%		0.0%	0.1%	0.7%		0.1%	0.2%	0.3%		0.0%	0.0%	0.0%

NOTES:
[a] n = 30, data from May 15, 2008 – December 4, 2010 (AEM, AREVA and Cameco unpublished data); [b] n = 20, data from June 13, 1999 – August 12, 2006 (GN, unpublished data); [c] n = 88, data from April 1, 1993 – December 4, 2010 (GN, unpublished data); [d] n = 20, data from April 19, 2000 – December 31, 2006 (GN, unpublished data); [e]n = 61, data from March 8, 2006 – June 30, 2010 (GNWT, unpublished data)



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.3-2_Caribou_Collar_Data_RAA_SnowFreeSeason.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., Gov't of NWT, and Gebauer & Associates.*

FIGURE 13.3-2
CARIBOU COLLAR DATA FOR ANIMALS ADJACENT TO AND WITHIN THE REGIONAL ASSESSMENT AREA DURING THE SNOW-FREE SEASON (MAY 26 - OCTOBER 31)
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500000 520000 540000 560000 580000 600000 620000 640000 660000 680000

7180000 7160000 7140000 7120000 7100000 7080000

Schultz Lake
Qamanaajuk Lake
Whitehills Lake
Skinny Lake
Aberdeen Lake
Siamese Lake
Long Lake
Thelon River
Thom Lake
Baker Lake
Judge Sissons Lake
Audra Lake
Pitz Lake
Princess Mary Lake

N

Area of Detail

Nunavut

Legend

- River
- Wetland
- Lake
- North All-Season Road

Caribou Collar Movements by Herd

- Baker Lake Herd 2008 - 2011 (GN)
- Wager Bay Herd 2000 - 2006 (GN)
- Lorillard Herd 1999 - 2006 (GN)
- Qamanirjuaq Herd 1993 - 2011 (GN)
- Beverly and Ahiak Herds 2006 - 2011 (GNWT)
- Kiggavik Lease
- Sissons Lease
- Regional Assessment Area

Nunavut

GN Caribou data collected and analysed by:
Mitch Campbell - Government of Nunavut, Department of Environment, Wildlife Division
Background:
Movement paths based on telemetry data collected between 1993 and 2011.

Government of Nunavut data should not be reproduced or distributed without written permission by the Government of Nunavut, Department of Environment, Wildlife Division.

0 2.5 5 10 15 20 Kilometres

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 04/10/2012 Scale: 1:500,000
File: 13.3-3_Caribou_Collar_Data_RAA.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., Gov't of NWT, and Gebauer & Associates.*

FIGURE 13.3-3
CARIBOU COLLAR DATA FOR ANIMALS ADJACENT TO AND WITHIN THE REGIONAL ASSESSMENT AREA

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Table 13.3-2 Caribou Seasonal Observations within the Kiggavik RAA

Activity	Estimated dates	Satellite Collar Locations and Observed Caribou within the RAA
Spring migration	March 16 – May 25	Qamanirjuaq — Caribou from the Qamanirjuaq herd have been documented within the southeastern portion of the RAA during this pre-calving season (GN unpublished data). Resident – Caribou from the Resident herd are regularly present within the RAA during this period.
Calving	May 26 – June 25	No collared animals observed during calving in the RAA. No historical evidence of caribou calving in the RAA.
Post-calving aggregation	June 26 – July 31	The Kiggavik RAA is located near the edge of post-calving areas for the Beverly herd (to the north) and the Qamanirjuaq herd (to the south). The RAA has traditionally been included within a broader post-calving area for the Beverly (not Qamanirjuaq). Qamanirjuaq — Satellite collar data show that 2009 was the first year that collared Qamanirjuaq animals have moved through the RAA during the post-calving period. Large numbers observed in 2009 and 2010 were most likely from this herd. Other – Several hundred animals (including cows and calves) were observed crossing the Thelon River from north to south in July 2010. Animals could have been from the Beverly/Ahiak, Resident or Qamanirjuaq herds.
Summer dispersal	August 1 – September 15	Caribou numbers increase in the RAA beginning at the end of the post-calving period and into the summer dispersal period. Based on recent collaring data, these caribou appear be primarily from the Qamanirjuaq herd. It is possible that some individuals were from the Resident and Beverly/Ahiak herds.
Rut and fall migration	September 16 – October 31	Beverly/Ahiak — At least one collared animal observed north of the RAA Qamanirjuaq — At least one collared animal observed south of the RAA
Early and Late winter	November 1 – March 15	Some collared animals (regardless of designated herd) that remain on the tundra have been found in the RAA.

13.3.2.3.2 HARVEST DISTRIBUTION IN THE RAA AND HARVEST TRENDS

Overview – Most of the Kiggavik RAA is a hunting area. The Judge Sissons Lake area is sometimes used as a travel route westwards to Aberdeen Lake, and the area is sporadically used for caribou hunting. To the east towards Baker Lake, in some years significant numbers of caribou wintered in the Princess Mary Lake area (south of the RAA). During those years, caribou were hunted from fall through to spring. Very little hunting or trapping activity was reported in the northwestern half of the RAA from 1960 through 1978 (NLUIS 1980). Recently, relatively few caribou were harvested in the RAA, based on harvest location statistics collected as part of the Nunavut Wildlife Harvest Study (NWMB 2005) and the ongoing Baker Lake HHS. Caribou harvest densities continue to be highest near and east of Baker Lake (20 km radius), and up to the Thelon River, west of which harvest rates decline sharply.

Road access has changed Baker Lake hunter behaviour. Prior to construction of the Meadowbank mine access road, 18% of the total caribou harvest by the community of Baker Lake was located within 5 km of the road, based on data from the 1996 to 2001 Nunavut Wildlife Harvest Study (NWMB 2005). Since the road was completed in 2008, the relative hunting pressure had increased to 36% of total harvest within 5 km of the access road. It is unclear whether the overall caribou harvest has increased disproportionate to the increasing trend observed since the late 1960s (summarized below and described in Tier 3, Appendix 6C) or if changes are independent of caribou density or distribution.

Based on recent collaring distribution data and local IQ, most of the caribou harvested in the Kivalliq region are likely from the Wager Bay, Lorillard, Qamanirjuaq and Resident herds. Animals from the Beverly and Ahiak herds are hunted primarily by the Dene of northern Saskatchewan, eastern Northwest Territories (NWT) and northern Manitoba (BQCMB 1999). Hunters from Baker Lake are the primary Nunavut-based hunters who harvest from the Beverly herd. August, September and October are traditionally the months of highest total caribou harvest in Baker Lake, based on the NWMB Harvest Study (NWMB 2005) and the Baker Lake HHS (see Tier 3, Appendix 6C).

Harvest Rates – Harvest statistics have not been consistently collected from Baker Lake households, and harvest trends are difficult to estimate. Since harvest records were not consistently gathered, there appears to be conflicting numbers among reports gathering information from successive decades. Annual caribou harvest recorded from 1969 to 1977 varied from 1,586 to 2,378 caribou, and total annual harvest for Baker Lake households in 1976/77 was estimated as 4,100 caribou (IDS 1978). Annual caribou harvest recorded from 1996 to 2001 ranged from 2,057 to 2,856 animals, but that was likely an underestimate (NWMB 2005). The current estimated caribou harvest by Baker Lake residents ranges from 2,000 to 6,000 caribou (see Tier 3, Appendix 6C).

Caribou harvest by Baker Lake hunters occurs at a ratio of 20:40:40 between the Beverly, Qamanirjuaq, and other caribou herds (BQCMB 2006). Using the harvest range of 2,000 to 6,000 animals, Baker Lake hunters may be annually harvesting 800 (BQCMB 2006) to 2,400 (Baker Lake HHS) Qamanirjuaq caribou (Table 13.3-3). Based on the BQCMB's (2008) total annual Qamanirjuaq caribou harvest of 9,070 animals, Baker Lake hunters are responsible for 8.8% of the total Qamanirjuaq caribou harvest (800/9,070).

Table 13.3-3 Baker Lake Community Harvest Estimates by Caribou Herds

Herd	Proportion Harvested by Baker Lake Hunters[1] (%)	Low Harvest Estimate of Qamanirjuaq[2]	High Harvest Estimate[3]
Beverly/Ahiak	20	400	1,200
Qamanirjuaq	40	800	2,400
Other (Resident, Wager Bay, Lorillard)	40	800	2,400

NOTES:
[1] The BQCMB estimates that Baker Lake harvest comprises 40% Qamanirjuaq, 20% Beverly, and 40% Other (BQCMB 2006)
[2] Out of a total 2,000 caribou harvested in Baker Lake
[3] Out of a total 6,000 caribou harvested in Baker Lake

There are no known legislated limits on subsistence hunter harvest. The GN recommends that no TAH be applied to the five populations (Government of Nunavut 2005). Campbell et al. (2010) attributes the BQCMB as designating a sustainable harvest as 5% harvest of the "standing stock," assuming the standing stock is 75% of a herd estimate. Harvest is adjusted by a factor of 1.25 to account for estimated wounding loss (Campbell et al. 2010). The total allowable harvest equates to 3.75% of the population estimate. Based on these assumptions and the 2008 population estimate for the Qamanirjuaq herd of 348,661 caribou (Campbell et al. 2010), the current annual sustainable harvest of Qamanirjuaq caribou is approximately 13,075 caribou per year. Baker Lake hunters account for 8.8% of the harvest, and theoretically can harvest up to 1,151 Qamanirjuaq caribou per year.

Assuming equal harvest pressure throughout the region, and a reasonably stable caribou population of about 350,000, the current Qamanirjuaq herd harvest estimates for Baker Lake indicate that:

a) The community could sustainably harvest an additional 351 (1,151 "allowable" minus the current estimated 800) Qamanirjuaq caribou using the BQCMB (2006) harvest estimate (using the lower harvest estimate, Table 13.3-3) and current caribou population estimate; or

b) The community may already be harvesting at a level that is cumulatively exceeding sustainable limits by 1,249 caribou (2,400 minus 1,151) using the higher harvest estimate (Table 13.3-3; Baker Lake HHS) and current caribou population estimate.

13.3.2.4 Effect Mechanisms and Linkages for Change in Mortality

The proposed North All-Season Road may have the greatest potential to affect caribou mortality because it will provide hunters access to an area that has been relatively inaccessible during the snow-free season. Mortality is greatest in areas where people are permitted to hunt or where hunting pressure is relatively high. Hunter access to previously inaccessible areas was reported to affect local populations of grouse (Fischer and Keith 1974), white-tailed deer (Fuller

1990), elk (Unsworth et al. 1993; Gratson and Whitman 2000) and caribou (Bergerud et al. 1984). Roads allow harvesters to cover larger hunting areas more quickly; therefore, animals that occupy habitat along the road will more likely be harvested.

The area west of the Thelon River has experienced relatively limited harvest pressure compared to the area around Baker Lake (NWMB 2005; Baker Lake HHS). The low harvest pressure in the Thelon River area is a combination of limited access and apparent lower caribou densities in most seasons, relative to other areas accessible by Baker Lake hunters. The Thelon River is currently a barrier to some summer hunters: once ice has formed on the Thelon River in early winter, harvesters have easier access to the area west of the river for hunting. Introduction of the proposed North All-Season Road would increase summer access to this area, which might result in an increased harvest of animals from this area.

Baker Lake hunters are known to use roads for hunting caribou. Although some hunters might continue to adhere to traditional hunting grounds, a number of hunters interviewed during the HHS and stakeholder engagement sessions stated the Meadowbank access road has provided easy access to caribou and is used to reduce time spent 'on the land'. Harvest frequency adjacent to the access road each year, relative to other areas, has remained almost constant since the HHS began in 2007.

Baker Lake harvesters were asked, "If access across the Thelon was improved, would you hunt west of the Thelon more frequently?" Most interviewees indicated that, if there were access to the area west of the Thelon River, they would use it when caribou were in the area. Some specific comments from hunters included[1]:

> "Yes, I am looking forward to a bridge crossing because now you have to travel further to get caribou."
>
> "A road would definitely increase my hunting trips West."
>
> "Yes, if I need caribou."
>
> "Maybe, if I need caribou."
>
> "I hunt close to town if possible."

[1] Comments from harvesters documented in Martin Gebauer memo to Areva on 31 May 2011. 'Status Report – Baker Lake Hunter Harvest Study Monitoring Program – Winter and Spring 2011 Trips'.

The North All-Season Road will provide access to a historically less accessible hunting area because harvesters will be able to cross the Thelon River using the proposed bridge or cable ferry (For more information on current and predicted changes in future land use see Volume 3-Part 2: Inuit Qaujimajatuqangit and Volume 9-Part 1: Socio-Economic Environment).

Although harvesting of animals can have a profound effect on caribou populations, it is not clear what level of harvest has an effect on barren-ground caribou. The GN, in their recommendations on TAH, state that "both scientific and Inuit information suggest that the ultimate cause of fluctuations in caribou population numbers is caribou grazing effects on range condition, rather than harvest levels*" (*Government of Nunavut 2005). Further, the GN does not feel it necessary, for conservation purposes, to regulate harvesting of caribou through a restriction on harvest season.

To date, the potential effects of resource road access in Nunavut have not been documented as a wildlife management issue for the GN. In their TAH report (Government of Nunavut 2005), the GN suggests that further strategic study is required to address information gaps on caribou populations. The report suggests:

- population monitoring using scientific air or ground surveys or telemetry devices attached to caribou
- surveys of parasite loads and effects of parasitism and disease on caribou population dynamics
- comprehensive mapping of habitat to monitor effects of habitat change over time on caribou population dynamics
- improved understanding of predator-prey dynamics
- further documentation of Inuit knowledge

The GN's Draft Caribou Strategy Framework (Government of Nunavut 2010) identified a growing need to address the effects of human use of the landscape on caribou populations.

13.3.2.5 Mitigation Measures and Project Design for Change in Mortality

Mitigation of potential increased mortality risk will involve AREVA and other parties such as the Baker Lake HTO and GN for harvest management and population assessment.

13.3.2.5.1 Mitigation by AREVA

AREVA will implement a number of mitigation measures to minimize the Project-related mortality risks on caribou populations interacting with the Project. Specific Project design measures are:

- Road alignment will minimize blind spots for drivers, thus reducing the potential for caribou-vehicle collisions.
- Road profile specifications and snow bank treatments will allow caribou opportunities to get off the road surface into adjacent areas and avoid traffic.
- Road will be designated for seasonal use (for the winter access road only).

Mitigation measures implemented during the Project phases include:

- preparation of an access management plan that incorporates the following features related to minimizing caribou mortality risk:
- seasonal road closures to all traffic during large caribou movements
- a no-shooting zone within a 1 km buffer either side of a road with no shooting allowed across the alignment
- road speed control to reduce the potential for caribou-vehicle collisions
- provision of wildlife monitors who will provide hazard warnings to drivers and implement restrictions on road travel during presence of high numbers (e.g., 100s) of caribou within 300 m of road alignment
- worker awareness (i.e., watch for wildlife)
- caribou mortality reporting protocol to mine environmental manager
- monitoring and documentation of observed caribou activity/encounters
- implementation of the Caribou Protection Measures as identified by the Kivalliq Inuit Association, Department of Indian Affairs and Northern Development, and GN Department of Environment

13.3.2.5.2 Mitigation by AREVA and Others

AREVA, in combination with other parties (e.g., Baker Lake HTO, Kivalliq Inuit Association, GN, other industrial operators) can work together to minimize direct and indirect mortality risks using the following mitigation and management strategies:

- requirement by AREVA that other industrial users who want to use the North Winter Road will follow the same mitigation measures adopted by AREVA; this could extend as far as joint convoys

- compliance monitoring by AREVA/Kiggavik wildlife monitors to confirm that other industrial users are employing these measures effectively
- operate in compliance and collaborate with the NWMB, GN, KIA and Baker Lake HTO to promote third-party compliance and facilitate the monitoring and management of any commercial, recreational or Aboriginal hunting restriction that may be issued under the authority of the NLCA. Collaboration may include providing resources to responsible Inuit and local organizations for monitoring and management programs related to the Kiggavik access road, which are deemed appropriate by all parties.
- use of wildlife monitors to document all hunter-associated caribou mortalities (e.g., number, location)

13.3.2.5.3 Mitigation by Other Organizations and Agencies

Government of Nunavut (GN) — In the draft Nunavut Caribou Strategy Framework (GN, Department of Environment 2010), the GN identified several action items that it would implement in relation to human disturbance and industrial development:

- **Action 3.1e:** Develop a set of general guidelines for mitigating development impacts on caribou.
- **Action 3.1f:** Develop recommendations on the methods and standards of research required to adequately monitor and mitigate impacts on caribou around sites of development.
- **Action 3.1g:** Work with industry to integrate short-term, local monitoring and mitigation activities into long-term, herd-level research programs the results of which will support future sustainable development and the management of caribou.

In the draft Strategy document, the GN identifies a policy statement "*While acknowledging the importance of subsistence harvesting and respecting Inuit rights to harvest as laid out in the NLCA, the GN recognizes the need to manage harvesting when necessary for the purposes of conservation, public safety or the humane treatment of animals. It is also recognized that there are numerous ways to manage harvesting which do not necessarily require regulations. Accordingly, the GN will:*

- **Action 5.1b**: Work with HTOs, RWOs and the Elders Advisory Committee to outline a code of conduct for caribou harvesting, drawing on traditional hunting practices.
- **Action 5.1c**: Work with partners and the Elders Advisory Committee to develop programs targeted at educating youth on hunting rights and responsibilities, and harvesting ethics.

- **Action 5.1d:** Where necessary, develop herd management plans, which may manage harvesting.
- **Action 5.1e**: Work with HTOs and other co-management partners to support harvest management based on the principles of IQ and Inuit systems of wildlife management as provided for under the NLCA."

Based on the policies and actions identified in the draft Strategy document, the GN's contribution towards mitigating the potential increased mortality risk across the region may include:

- enhanced assessment and monitoring of caribou populations to better estimate current populations and trends of the 6 herds that interact with the Project
- documentation of mortality (natural and otherwise) to better understand long-term sustainability of the various herds

Other agencies may consider the following:

- enhanced monitoring of caribou herds and documentation of mortality by Nunavut Department of Environment, KIA, and HTO to better understand long-term sustainability of the various herds
- initiatives by HTOs, KIA, GN, BQCMB, NWMB and communities that ensure the long term viability of traditional, resident and sport harvest
- monitoring and documentation of caribou kills, by community

13.3.2.6 Residual Cumulative Effects for Change in Mortality

The Project could result in adverse effects on caribou through direct and indirect increase to caribou mortality risk. Direct mortality could result from caribou-vehicle collisions. Effects of the Project could also act cumulatively with similar effects from other industrial projects, other road traffic and improved access for traditional and recreational hunters. The cumulative effects would be of particular concern if the North All-Season Road option were to be selected because hunter access would be provided to the area west of the Thelon River, a region with historically and currently low hunting pressure.

Assuming equal harvest pressure throughout the region, the current Qamanirjuaq herd harvest estimates for Baker Lake indicate that:

- the community could either sustainably harvest an additional 351 Qamanirjuaq caribou using the BQCMB (2006) harvest estimate (using the lower harvest estimate; Table 13.3-3) and current caribou population estimate or
- the community is already harvesting at a rate that is exceeding sustainable limits by 1,249 caribou using the higher harvest estimate (Table 13.3-3; Baker Lake HHS) and current caribou population estimate

13.3.2.6.1 Mine and North All-Season Road

The North All-Season Road option will increase the mortality risk to the Qamanirjuaq caribou during the snow-free season by facilitating hunter access. While caribou-vehicle collisions may occur, the identified mitigation measures will make these events unlikely. The magnitude of the effects regarding the interaction of the Project with the caribou herds is expected to be low. The frequency of increased mortality risk is continuous and will occur throughout the duration of the Project; however, the effects are expected to be local. The residual effects will be reversible, following decommissioning of the road during the final closure phase.

The Qamanirjuaq herd is unlikely to be affected by increased harvest pressure due to the North All-Season Road because few of the collared caribou have been recorded occurring in the Kivalliq region. Most of the Baker Lake resident harvest of Qamanirjuaq caribou is occurring elsewhere in the Kivalliq region (i.e., likely south of Baker Lake). The Qamanirjuaq caribou herd collar location data was collected from 1993 to 2010 and is assumed to be representative of the Qamanirjuaq herd movement during the past two decades; however, caribou movements and habitat use is more dynamic than previously thought, so the fact that Qamanirjuaq caribou have not used the area much in the past does not mean that they will not use the area extensively in the future. Overharvest of the Qamanirjuaq caribou herd may or may not be currently occurring; there is too much uncertainty with the harvest estimates and caribou population estimates to be certain of the population size and current harvest rates. Regardless of the current harvest, the effect of North All-Season Road on hunter access and, consequently, caribou mortality is expected to be undetectable at the scale of the Qamanirjuaq caribou herd's current population.

The North All-Season Road will increase harvest pressure on the Resident herd, but it is difficult to determine if or how this harvest will affect the population of caribou because there are no population estimates for the Resident herd. The Resident caribou herd collar location data represents less than two years of data collected between 2008 and 2010. Although the collars indicate that the Resident herd occurs primarily west of the proposed North All-Season Road, north of the RAA and around Baker Lake, the short data collection period results in low confidence that this distribution accurately reflects the range used by the Resident herd.

The Wager Bay herd is unlikely to be affected by the North All-Season Road because the majority of the herd's range is north of the Thelon River and the herd is already accessible from the Baker Lake community. Wager Bay caribou collar location data were collected between 2000 and 2006 and is probably representative of the herd's distribution.

13.3.2.6.2 Mine and Winter Roads

A winter access road is not expected to be used by Baker Lake hunters for gaining access to areas for hunting caribou. As such, mortality risk is not expected to increase as a result of hunter access during the winter. The effects at the caribou population level will be undetectable. The magnitude of potential cumulative effects on caribou mortality risk is expected to be negligible.

13.3.2.7 Determination of Significance for Cumulative Change in Mortality

The magnitude of cumulative effects on caribou mortality risk is predicted to be negligible. Any effect will be undetectable at the local scale, will occur continuously during mine operation, and is reversible following final closure of the Project (i.e., once traffic ceases the risk of a collision mortality also ceases). Confidence is moderate for the prediction of a negligible effect because the largest effect on mortality is the indirect effect of increased hunter access. Successful mitigation of potential increased harvest effects is a joint responsibility. The overall success is dependent on the ability of all parties to be engaged and to work collaboratively.

After mitigation, the mine and access road options will result in a not significant adverse effect on caribou mortality risk on the Resident and Wager Bay caribou herds. The Project is not expected to interact with caribou from these herds in a manner that will increase mortality risk from harvest. The mine and winter access road options are expected to result in not significant adverse effects on Qamanirjuaq caribou because these caribou should be mostly absent from the RAA during the winter season. The North All-Season Road has the potential to provide access to the RAA during the snow-free season when Qamanirjuaq caribou are in the area, which could increase the proportion of Qamanirjuaq animals taken only in the late July/August season. However, application of mitigation measures (e.g., improved monitoring and promotion of hunting allocations and techniques by the HTO among other potential measures) will help manage the potential for increased mortality risk from harvest.

13.3.2.8 Residual Cumulative Change in Mortality

Mitigation of the potential increase to mortality risk requires participation from AREVA, partners, and management agencies. AREVA is confident that the mitigation options suggested above as their responsibility will be effectively conducted. Road closures and no harvest zones within 500 m of the road are expected to be effective at minimizing caribou mortality directly related to road access. AREVA cannot predict how mitigation managed by other parties will be conducted.

The Kiggavik Project's effects on mortality risk will be limited to a small risk of road collisions and harvester access provided by an all-season road. The effects will be limited to the RAA and the caribou herd that is in the RAA during the ice-free season (a portion of the Qamanirjuaq herd). It is likely that Baker Lake harvesters will harvest a greater proportion of Qamanirjuaq caribou during the ice-free season when compared to current harvest patterns.

13.3.2.9 Determination of Significance for Cumulative Change in Mortality

A sustainable mortality rate was attributed to the BQCMB by Campbell et al. (2010) as 3.75% of a herd's population estimate. Given current estimates of proportional hunting pressure on herds in the Baker Lake area (BQCMB 2006) and estimated hunter harvest rates, hunting by Baker Lake harvesters may already be contributing to unsustainable harvest levels on the Qamanirjuaq herd. Assuming a mid-level of harvest in Baker Lake (4,000 animals), 1,600 may be from the Qamanirjuaq herd. These numbers in themselves are not significant on a population level; however, in combination with harvest and other mortality factors across their range, an exceedance of a sustainable mortality level cannot be discounted. A considerable amount of uncertainty exists with data used to generate this estimate, and results should be taken with caution. Improved road access will likely increase the proportion of Qamanirjuaq animals taken in the late July/August season only.

The contribution of the Project to cumulative effects on mortality risk to caribou, and ultimately to the sustainability of the Qamanirjuaq and Baker Lake caribou herd populations will be not significant. While access options could have an indirect effect on caribou harvest, it is not clear if that harvest will be additional or compensatory to what is already harvested by Baker Lake Hunters. The Qamanirjuaq herd seems to be the herd at greatest risk of increased harvest as a result of harvester access during the ice-free season. However, it appears as if only a small portion of the herd is found in the RAA when the road provides access, and they are only there for a brief time. It is possible that tens of additional caribou could be harvested in the brief time that they are in the RAA. However, the determination of this possible effect is based on broad estimates of both current harvest rates, harvest proportion by herd and current caribou population numbers. Better knowledge of all are necessary for the certainty of the assessment to be increased.

AREVA considers it a high priority to work with interested parties on implementing effective and consistent mitigation to manage the potential increased mortality risk as a result of the all season road access.

13.3.2.10 Compliance and Environmental Monitoring for Change in Mortality

Compliance and environmental monitoring for changes in mortality to caribou and muskox includes the following:

- continued participation in the HHS (helps to determine total harvest by herd)
- continue participation in the GN-led caribou collaring program (determine seasonal distribution by herd)
- support GN-led herd delimitation and population estimate survey (determine regional herd population trends)
- continue Project-specific caribou monitoring programs (e.g., ground-based observations)

13.3.3 Assessment of the Cumulative Effects: Change in Habitat Availability

The Project in isolation is not expected to result in a significant adverse effect on caribou habitat within the Qamanirjuaq caribou herd growing season range or the Baker Lake caribou herd winter range. The Project is not expected to result in a significant loss of muskox habitat within GN Wildlife Management Unit MX/21.

Although the residual effects of the Project on changes in habitat availability are not significant, the effects could act cumulatively with similar effects from other human activity in the region that affects caribou herds or muskox. The cumulative effect of the habitat loss across the range could reduce the overall availability of habitat for wildlife in the region to a point that population level effects occur.

13.3.3.1 Effect Mechanisms and Linkages for Cumulative Change in Habitat Availability

The cumulative direct loss of caribou and muskox habitat will reduce the amount of available habitat regionally, but this effect will not result in measurable or detectable changes in the region. Indirect loss of wildlife habitat from human disturbance that results in avoidance is the largest source of habitat loss in the region. While human disturbance causes a loss of habitat, the effect is temporary as it occurs only while there is human activity. For the Project to cause a significant additional functional loss of habitat in the region, other human disturbances need to overlap temporally and within the ranges of wildlife that could be affected.

Current human disturbance within the growing season range of the Qamanirjuaq caribou herd that reduce the availability of habitat include:

- Meadowbank Mine – The footprint of the mine and mine access road has reduced the availability of habitat for wildlife. Activity at the mine site and transportation to the mine from Baker Lake has indirectly reduced the availability of wildlife habitat in the area. The Meadowbank Mine is expected to operate until 2019.
- Mineral Exploration Operations – There are numerous mineral deposits being explored in the region. Each of these operations has some amount of human activity (e.g., drilling, surveying). Exploration activities mostly take place during the summer and the footprint of the camps, drill pads and other disturbances is relatively small.
- Local Communities – The footprint of Arviat, Whale Cove, Rankin Inlet, Chesterfield Inlet and Baker Lake reduces the availability of habitat for regional wildlife. Sensory disturbance from vehicles, generators, aircraft traffic and other human activities in these communities indirectly reduce the availability of wildlife habitat. These communities are permanent fixtures on the landscape of the Qamanirjuaq herd.

Current human disturbance within the winter range of the Baker Lake caribou herd that reduce the availability of habitat include Meadowbank Mine and mineral exploration operations, as described above, as well as the footprint of Baker Lake, a permanent fixture on the Baker Lake herd.

Current human disturbance within muskox wildlife management unit MX/21 that reduce the availability of habitat includes mineral exploration operations.

The Kiggavik Project will add to the overall habitat loss within the seasonal ranges of the Qamanirjuaq and Baker Lake caribou herds, and the regional muskox population. While there are a number of mineral exploration operations in the region, few exploration projects turn into active mines. Therefore, it is unlikely that the Project will overlap temporally with operating mines or other industrial developments in the region.

13.3.3.2 Mitigation Measures for Cumulative Change in Habitat Availability

Mitigation measures for cumulative changes in habitat availability are the same as those presented for the Project Case.

13.3.3.3 Residual Cumulative Change in Habitat Availability

Project mitigations are designed to reduce the Project effects on wildlife. By reducing Project specific effects, AREVA is reducing the potential for adverse cumulative effects on wildlife in the Kivalliq region. The option with the largest potential effect on terrestrial wildlife is the mine and

North All-Season Road option. Assuming habitat loss at the Meadowbank mine and each of the communities is similar in magnitude and extent as the proposed Kiggavik mine and North All-Season Road, then the total:

- growing season habitat loss for the Qamanirjuaq herd is 1.4% (5 communities, Meadowbank mine and Kiggavik)
- winter season habitat loss of the Baker Lake caribou herd is 1.5% (Baker Lake community and Meadowbank mine)
- growing and winter season habitat loss for muskox within the local wildlife management unit (MU) remains at 3.7 and 3.1%, respectively

Because there are no other industrial developments or communities within the MU, these values exclude the potential effects of mineral exploration in the area; however, exploration activities are expected to be a not significant cause of habitat loss.

13.3.3.4 Determination of Significance for Cumulative Change in Habitat Availability

Currently, there are few human activities in the region that affect wildlife. The Meadowbank mine and regional communities are currently the greatest sources of habitat loss for wildlife. The addition of the Kiggavik Project to these disturbances is not expected to measurably reduce the amount of caribou and muskox habitat. Mineral exploration is currently not causing substantive loss of habitat. Although there is the potential for future mine development in the region, given the history of such development the likelihood of multiple future mines existing at the same time as the Kiggavik Project is low. The cumulative change to habitat availability for caribou and muskox is, therefore, assessed as not significant.

13.3.3.5 Compliance and Environmental Monitoring for Cumulative Change in Habitat Availability

Compliance and environmental monitoring for cumulative changes in habitat availability are the same as those presented for the Project Case.

13.3.4 Summary of Project Cumulative Environmental Effects on Terrestrial Wildlife and Habitat

Table 13.3-4 summarizes the cumulative environmental effects of the Project on caribou and muskox.

Table 13.3-4 Summary of Residual Cumulative Environmental Effects on Caribou and Muskox

Cumulative Environmental Effect	Case	Other Projects, Activities and Actions	Mitigation and Compensation Measures	Residual Cumulative Environmental Effects Characteristics							Significance	Prediction Confidence	Likelihood	Proposed Follow-up and Monitoring Programs
				Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Changes in Mortality Risk	Cumulative Effect with Project (Future Case)	Meadowbank Mine access road, harvesting activities across ranges		N	N	N	MT	R	R	D	N	M	N/A	Agency responsibility
	Project Contribution to Cumulative Effect	Unintended harvester access		N	N	N	MT	R	R	U	N	M	N/A	Private road, road closure, access management
Changes in Habitat Availability	Cumulative Effect with Project (Future Case)	Meadowbank Mine, various exploration operations, and various regional communities	Dust management; Minimize Project footprint; Progressive reclamation	N	L	N	LT	C	R	D	N	M	N/A	Contribution to collaring program
	Project Contribution to Cumulative Effect	NA	NA	N	L	N	LT	C	R	U	N	M	N/A	Quantify Project footprint on an annual basis

Table 13.3-4 Summary of Residual Cumulative Environmental Effects on Caribou and Muskox (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible: No anticipated effect on wildlife species.

L Low: Observable effect on wildlife species but not likely to affect the species' sustainability in the Project area.

M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the region.

H High: Measurable effect on wildlife species but that will likely affect the species' sustainability in the region.

Geographic Extent:

S Site specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities.

13.4 SUMMARY OF RESIDUAL EFFECTS ON CARIBOU AND MUSKOX

13.4.1 Project Effects

The residual Project effects on caribou mortality risk, caribou and muskox habitat, caribou movement, and caribou and muskox health are assessed as not significant. Collar data from the local and regional herds shows that few caribou are expected to interact with the Project. Caribou from the Qamanirjuaq and Baker Lake caribou herds are the most likely to occur within the RAA during the growing and winter seasons, respectively. The Projects potential to affect mortality is readily mitigated by controlling human access and by speed limits on the proposed roadways. The effect of the Project on habitat will be small at the scale of the caribou herd ranges. Muskox are not expected to experience a reduction in habitat availability at the scale of the GN's wildlife management unit. The Project is not anticipated to result in significant adverse effects to caribou movement because the Project is not located on any migratory routes, is not within 10 km of any designated water crossing, and mitigations will reduce potential Project effects on caribou movement. No residual effects on caribou and muskox health are anticipated because of exposure the COPCs.

13.4.2 Cumulative Effects

The effects on movement and health will be undetectable and those effects are not expected to act in combination with any other Project-specific effects. Changes in increased mortality risk and habitat loss may act in combination with effects from other future projects for cumulative effects. However, the increased mortality risk is the result of potential hunter/harvester access, and the role of habitat loss is expected to be undetectable as it relates to potential harvest success in the RAA. When considered in the context of cumulative effects, the Project effect on the cumulative loss of habitat and increased cumulative mortality risk on Qamanirjuaq caribou is assessed as not significant. Mulit-party participation may be required to mitigate the potential effects of the increased mortality risk (i.e., assess and manage hunter access and determine sustainable levels of harvest).

13.4.3 Effects of Climate Change on Caribou and Muskox

While it is difficult to provide any degree of certainty, it is likely that climate change will affect habitat in a number of ways. In subarctic and mid-arctic habitats, studies have already demonstrated that warming temperatures are increasing the productivity of vegetation; encouraging the growth of shrubs and graminoids, and decreasing the cover of mosses and lichens (Cornelissen et al. 2001; Sturm et al. 2001; Walker et al. 2006). This could have implications for habitat use by caribou through a decrease in forage food cover (e.g., lichen) and an increase in snow depth, possibly resulting in habitat use changes during the winter season. However, an increase in shrub growth would also provide increased forage for both caribou and muskox in the spring and summer months.

Climate and ultimately, weather, directly influences the body condition of caribou, which in turn affects survival and mortality rates. Caribou survival is influenced by a number of climate-related parameters at different times throughout the year. Climate variability (i.e., mean positive and negative variations in temperature) can influence factors that affect caribou mortality directly, such as summer insect harassment, or indirectly, such as winter severity (via snow hardness and depth), and spring snow free date (via natural mortality and predation risk) (Gunn et al. 2011). If a suite of negative climate conditions for caribou occurs (i.e., deep winter snow, hard snow crust, late spring snow free date, and extreme summer insect harassment), survival rates will undoubtedly decrease from baseline conditions. However, these effects will likely not be detectable within the 20- to 30-year life of the Project.

The most substantive effect of climate change on wildlife may be an increase in the frequency and magnitude of weather extremes (Gunn 1995). There are no identifiable mechanisms for climate change to exacerbate or decrease direct mortality of wildlife from transportation collisions or indirect mortality from harvesters gaining access to previously rarely hunted areas.

There is considerable uncertainty when assessing the effects of climate change on the Project and cumulative effects on terrestrial wildlife and habitat. Although historic trends often correlate well with observed conditions, the unpredictable nature of climate change science adds considerable complexity to effects assessment. Climate change could have potentially positive or negative effects on wildlife and habitat. An evaluation of the historical and climate change water balance for Pointer Lake and Judge Sissons Lake at the Kiggavik site (Tier 3, Appendix 5K) found that on average, climate models predict a 34% increase in precipitation which is typically distributed throughout the year, with the most dramatic increases occurring in the autumn. Contrary to the expected increase in precipitation, snowfall in the Baker Lake area has decreased since 1993, but has not steadily declined; instead, it has stabilized at a lower level. At the latitude of the Kiggavik Project, there is an expected increase in mean annual ambient surface temperature of 5.2°C in the next 100 years (Tier 3, Appendix 4D). More detailed climate analyses for the Baker Lake area are available in Tier 3, Appendices 4D and 5K.

The confidence in any prediction of climate change is low. Effects on caribou and muskox populations may occur gradually throughout the life of the Project, yet it is largely unknown how or if wildlife will be able to adapt to these conditions. The relatively short life of the Project means that it is unlikely that climate change will exacerbate Project effects on terrestrial wildlife or habitat.

13.5 SUMMARY OF MITIGATION MEASURES FOR CARIBOU AND MUSKOX

The winter road options are key Project design features that will mitigate many of the Project potential effects on caribou and muskox. Controlled public access to the roadways will further mitigate the potential increased mortality of caribou and muskox along the road options. Dust dispersal, which can lead to habitat loss, will be mitigated from the tailings management facility through subaqueous deposition of tailings. Minimizing the Project footprint will reduce the overall loss of available habitat. The North All-Season Road will be constructed of finer material and will have a reduced embankment to mitigate potential caribou movement effects across the roadway. Other AREVA environmental policies and mitigation measures that will reduce potential Project effects on caribou and muskox include:

- restricting personnel from carrying firearms for the purpose of hunting while on site
- a policy that restricts wildlife harassment
- controlled public traffic along roadways
- temporary roadway shutdowns when caribou are migrating through the LAA
- reducing road activity during important seasonal migratory seasons and during post-calving
- reducing road speed limits
- minimizing Project activities outside of the footprint
- providing dust suppression along roads during dry summer periods
- progressively reclaiming disturbed areas
- snow management that avoids long continuous cuts or piles of snow that could restrict spring migration across roadways
- avoiding construction activities within 10 km of designated water crossings during 15 May to 1 September, in accordance with the DIAND Caribou Protection Measures
- minimizing the use of fencing and, where required, minimize the lengths of fencing unless required for safety

13.6 SUMMARY OF COMPLIANCE AND ENVIRONMENTAL MONITORING FOR CARIBOU AND MUSKOX

Compliance and environmental monitoring for change in mortality to caribou and muskox will include the following:

- continue HHS (helps to determine total harvest by herd)
- continue participation in Caribou Collaring Program (determine seasonal distribution by herd)
- support GN-led herd delimitation and population estimate survey (determine regional herd population trends)
- continue Project-specific caribou monitoring programs (ground-based observations)

AREVA will monitor the Project footprint on an annual basis to assess the footprint area for changes in habitat availability. Continued contributions to a government-led caribou collaring program will provide future information on the response of caribou to habitat disturbance in the Kivalliq region.

AREVA will conduct the following monitoring for change in movement of caribou and muskox:

- continued contributions to a government-led caribou collaring program
- monitoring caribou use of water crossing that are within 10 km of the Project activities
- seasonal monitoring of caribou movement prior to caribou entering the RAA as a proactive way of providing information that will advise temporary shutdown of traffic on roads

No specific monitoring requirements are recommended based on the assessment for change in health of caribou and muskox. The monitoring of other environmental components (e.g., water, vegetation [i.e., specifically lichen]) will provide valuable information for confirming the results of the assessment.

14 EFFECTS ASSESSMENT FOR RAPTORS

14.1 SCOPE OF THE ASSESSMENT FOR RAPTORS

The raptor effects assessment focuses on the indicator species peregrine falcon. Other raptors that occur within the RAA either exist at low densities and a change from baseline condition would be undetectable or effects would be linked to effects on the indicator species; and the proposed mitigation measures would also reduce the potential for these populations to be affected by the Project.

14.1.1 Project-Environment Interactions and Effects

Project activities during construction, operation and closure have the potential to affect the habitat, nest productivity and health of raptors within the Kiggavik RAA. Key effects on peregrine falcon include:

- reduced habitat availability from the Project infrastructure footprint that results in a direct loss of foraging habitat, and sensory disturbances that result in an indirect loss of functional habitat
- indirect effects of reduced nest site productivity from sensory disturbances from mine operations and road traffic at nests close to these activities
- change in health due to radionuclide and metal content transfer through the food chain

Project components and activities related to these potential effects are listed in Table 14.1-1. These components include site clearing (habitat loss), mine operation (reduced habitat effectiveness), road construction (habitat loss) and operation (reduced habitat effectiveness), milling (noise affecting habitat effectiveness and dust affecting forage and ultimately raptor health). When activities occur near nest sites (within auditory or visual range), disturbance of incubating or brooding adults may result in reduced nest productivity.

Table 14.1-1 Project-Environment Interactions and Effects on Raptors and Habitat

Project Component	Project Activities	Environmental Effects		
		Change in Habitat	Change in Productivity	Change in Health
Construction				
On-Land Construction	Site clearing and pad construction (blasting, earth moving, loading, hauling, dumping, crushing)	✓		
Supporting Activities	Transport fuel and construction materials		✓	
Operation				
Mining	Mining ore (blasting, loading, hauling)		✓	✓
Milling	Crushing and grinding			✓
Ongoing exploration	Aerial surveys		✓	
NOTES: Only Project interactions ranked as 2 in Table 11.5-1 are carried forward to this table. A ✓ indicates that an activity is likely to contribute to the effect.				

14.1.2 Residual Environmental Effects Criteria for Raptors

Residual effects on raptors and raptor habitat were characterized quantitatively and qualitatively using the following six attributes: magnitude, geographic extent, duration, frequency, and reversibility. Table 14.1-2 provides definitions for these attributes.

Table 14.1-2 Residual Environmental Effects Criteria for Raptors

Attribute	Description	Rating	Definition
Direction	The ultimate long-term trend of the environmental effect	Positive	Increased habitat availability (cliffs), increased productivity or improvements to health relative to baseline conditions
		Neutral	No change in habitat availability, productivity or health
		Adverse	Reduced habitat quality, productivity and health
Magnitude	Amount of change in a measurable parameter relative to baseline conditions	Negligible	No measurable change from baseline conditions.
		Low	Observable effect on wildlife species but not likely to affect the species' sustainability in the LAA.
		Moderate	Observable effect on wildlife species but not likely to affect the species' sustainability in the RAA.
		High	Population-level detectable change to habitat availability, productivity and health of the Peregrine Falcon *tundrius* population

Table 14.1-2 Residual Environmental Effects Criteria for Raptors (cont'd)

Attribute	Description	Rating	Definition
Geographic Extent	The geographic area within which an environmental effect occurs	Local	Effect confined within the LAA
		Regional	Effect extends beyond the LAA but within the RAA
		Territorial	Effect extends beyond the RAA but within Nunavut
		National	Effect extends beyond Nunavut but within Canada
Frequency	Number of times that an effect may occur over the life of the Project	Once	Effect occurs once
		Sporadically	Effect occurs occasionally but not consistently throughout the life of the Project
		Regularly	Effect occurs at regular intervals throughout the life of the Project
		Continuous	Effect occurs continuously throughout the Project
Duration	Length of time over which the effect is measurable	Short term	Less than one year
		Medium term	More than one year, but not beyond the end of Project decommissioning
		Long term	Beyond the life of the Project
Reversibility	Likelihood that a measurable parameter for a VEC will recover from an environmental effect to baseline conditions	Reversible	Will likely recover to baseline conditions after or before the end of Project decommissioning
		Irreversible	Unlikely to recover to baseline conditions after the end of Project decommissioning

14.1.3 Standards or Thresholds for Determining Significance

There are no known published standards or thresholds for determining effect significance on raptor habitat or nest productivity. In the absence of legislated or otherwise identified thresholds, the significance of effects are determined based on professional judgment and knowledge of peregrine falcon ecology and behavior in eastern Arctic Canada. Determination of whether a Project's residual effect on raptors is considered significant is based on whether the effect influences the long-term viability of a population or delays its recovery. A residual effect is considered not significant if the effect causes a change in the condition of an individual or population (or their habitat) that is within the range of natural variability or does not affect the integrity of a population in a measurable way.

Habitat – There is no known existing standard or threshold for determining a significant loss of raptor habitat. Based on professional opinion from experience on other northern projects and knowledge of raptor ecology, Project effects on habitat availability are considered significant if more than 10% of the habitat units within the RAA are directly affected by the Project.

***Productivity* –** Based on a review by Millsap et al. (1998), the Alberta Peregrine Falcon Recovery Team (2005) considers 1.25 chicks/territorial pair/year to reflect a productive population. A significant effect on productivity is when average productivity for the nests located within the RAA drops below 1.25 chicks/territorial pair/year.

***Health* –** There are no generic guidelines for Nunavut or Canada that are applicable to assess the effect of changes in biota based on their exposure to COPC. For this assessment, the estimated exposure to COPC by birds is compared to values that are set to be protective of health and if the exposure is lower than this value then no adverse effects are expected. The estimated dose received by the biota from exposure to radioactivity, considering both baseline and Project emissions, is compared to a level that is protective of birds.

14.2 EFFECTS ASSESSMENT FOR RAPTORS

14.2.1 Assessment of Change in Habitat Availability

Habitat availability for raptors can be affected by human developments through two pathways:

1. Direct habitat loss caused by development of the Project footprint will reduce habitat availability.
2. Indirect habitat loss from human disturbance associated with the Project that causes a functional loss of habitat.

The Kiggavik Project will result in a loss of raptor habitat. The Project footprint will reduce the quality of some foraging and nesting habitat for raptors. Effects on habitat from the Project could act cumulatively with similar effects from other human activity in the area.

14.2.1.1 Analytical Methods for Change in Habitat Availability

To assess the overall loss of peregrine falcon habitat availability within the RAA, a habitat unit index was developed. The index is based on assigning a ranked value to each habitat class (e.g., high=3, moderate=2, low=1, nil=0), and summing the available habitat, measured in hectares, weighted by the value of each class. The difference in the weighted sum of available habitat for from the baseline conditions, and the predicted direct and indirect loss of habitat indicate the expected loss of peregrine falcon habitat.

Direct loss of habitat was determined by overlaying the Project footprint onto the ELC map and calculating the total area affected for each ELC map unit. Indirect loss of habitat was assessed by reducing habitat quality (ELC unit quality) for the growing season within the mine site and access road options. Habitat quality within the mine site and road ZOIs were reduced by two categories to a minimum of low within 2 km of the mine footprint, and by one category to a minimum of low within 3 km of the mine footprint. The winter roads do not cause result in

indirect habitat loss because the roads will are decommissioned each year prior to breeding bird arriving in the RAA. Consequently, there will be no human disturbance along the road during the growing season. The peregrine falcon ZOI distances were based on published literature of recommended buffer zones for falcon nesting sites. The Ontario Ministry of Natural Resources suggests a setback 600 to 1000 m (or 400 to 760 m agl for aircraft; OMNR 1987). A setback of 1.6 km is recommended for construction related activities taking place over extended periods (Holthuijzen et al. 1990; Richardson and Miller 1997).

14.2.1.2 Baseline Conditions for Change in Habitat Availability

Suitable nesting habitat for peregrine falcon includes steep rocky areas and cliffs. Foraging habitat is determined by the density of available prey, which is primarily birds. The most common prey items are passerines (i.e., snow bunting, lapland longspurs, horned lark, and American pipit), but shorebirds, lemmings, and arctic ground squirrels are also taken. A description of the ELC units and their value to peregrine falcons as nesting and foraging habitat is presented in Table 14.2-1.

Peregrine falcons were one of the most common raptor species encountered during baseline field programs. Nesting birds were closely associated with steep terrain including cliffs and rock outcrops. Although the entire RAA was not surveyed, observers noted that most suitable peregrine falcon habitats near the mine and North All-Season Road were occupied by nesting birds suggesting that the Kiggavik RAA was saturated with nesting falcons.

Table 14.2-1 Description and Relative Value of ELC Units for Peregrine Falcons during the Growing Season within the RAA

ELC Unit	Growing Season Ranking	Reasoning
Water	Moderate	Water provides foraging habitat for raptors during the growing season because of the abundance of waterbirds (i.e., prey) that occur on or around waterbodies
Sand	Moderate	This ELC unit is poorly represented within the Kiggavik RAA, but many potential prey species (e.g., shorebirds) use this habitat type
Gravel	Moderate	This ELC unit is poorly represented within the Kiggavik RAA, but many potential prey species (e.g., shorebirds) use this habitat type
Rock Association	Moderate	Prey such as lemmings and arctic hares use this habitat type during the growing season. Rocks also provide camouflage and perching locations for raptors, and occasionally nest sites
Wet Graminoid	Moderate	Habitat contains prey (i.e., waterbirds, upland birds) for raptors during the growing season
Graminoid Tundra	Moderate	Habitat used by prey (i.e., waterbirds, upland birds) during the growing season.; however, the habitat provides little cover and few perches for raptors
Graminoid/ Shrub Tundra	Moderate	Rated moderate quality habitat for waterbirds and upland birds, so the habitat contains prey for raptors during the growing season

Table 14.2-1 Description and Relative Value of ELC Units for Peregrine Falcons during the Growing Season within the RAA (cont'd)

ELC Unit	Growing Season Ranking	Reasoning
Shrub Tundra	High	Rate high quality habitat for upland birds, so the habitat contains abundant prey for raptors during the growing season
Shrub/Heath Tundra	Moderate	Rated moderate quality habitat for upland birds, so the habitat contains moderate prey for raptors during the growing season
Heath Tundra	High	Rated high quality habitat for upland birds, so the habitat contains abundant prey for raptors during the growing season
Heath Upland	High	Rated high quality habitat for upland birds, so the habitat contains abundant prey for raptors during the growing season
Lichen Tundra	Moderate	Rated moderate quality habitat for upland birds, so the habitat contains prey for raptors during the growing season
Heath Upland/Rock Complex	Moderate	Rated moderate quality habitat for upland birds, so the habitat contains prey for raptors during the growing season

14.2.1.3 Effect Mechanisms and Linkages for Change in Habitat Availability

The Project will result in a direct loss of raptor foraging habitat because of the Project footprint. The Project footprint is expected to provide no usable habitat for raptor forage (birds) once the Project is constructed. The Project will also result in an indirect loss of raptor forage habitat because of human disturbance (i.e., noise, movement) near the Project footprint. Although never specifically studied, dust dispersion from road traffic may affect raptor activities at nests adjacent to the North All-Season Road. To determine the zones of influence of Project-related activities on raptor habitat, habitat protection guidelines were reviewed. The Ontario Ministry of Natural Resources suggests a setback distance of 600 to 1000 m (or 400 to 760 m agl for aircraft; OMNR 1987). A setback of 1.6 km is recommended for construction related activities taking place over extended periods (Holthuijzen et al., 1990; Richardson and Miller, 1997). As a conservative approach, this was translated to a 3 km ZOI, where within the first 2 km of Project activities, habitat suitability was reduced by two classes to a minimum of low, and by one class to a minimum of low from 2 to 3 km from Project activities (discussed in Section 14.2.2.4).

14.2.1.4 Mitigation Measures and Project Design for Change in Habitat Availability

AREVA will mitigate potential adverse effects on raptor habitat through:

- minimizing the Project footprint
- minimizing Project activities outside of the footprint
- progressively reclaiming disturbed areas

- providing dust suppression along roads during dry summer periods to reduce disturbance to nests adjacent to the north all-season road corridor
- eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings
- in the case of the winter road options, reducing the Project footprint will mitigate habitat loss and reduce the likelihood of the Project acting cumulatively with other Projects in the Kivalliq region

14.2.1.5 Residual Effects for Change in Habitat Availability

14.2.1.5.1 Mine and North All-Season Road

After mitigation, the mine site and North All-Season Road will result in a direct loss of 1,704 ha of previously usable Peregrine Falcon habitat. The Project is anticipated to reduce the availability of high and moderate quality habitat by 90.0% and 67.5%, respectively, within the LAA and by 14.5% and 5.8%, respectively, within the RAA (Table 14.2-2). This equates to an overall reduction of 49.7% habitat units within the LAA and 5.8% habitat units within the RAA (Figure 14.2-1).

Table 14.2-2 Peregrine Falcon Habitat Baseline and Predicted Effects for the Mine Site and North All-Season Road

	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	
Area	Class	Value	ha	ha	ha	ha	%
LAA	High	3	46,604	-977	-40,970	4,657	-90.0
	Moderate	2	50,169	-726	-33,129	16,314	-67.5
	Low	1	0	0	74,098	74,098	NA
	Nil	0	0	0	1,704	3,407	NA
	No Rating		163	0	0	163	0.0
	Total		96,936	-1,704	1,704	98,639	-49.7
RAA	High	3	322,218	-768	-45,850	275,600	-14.5
	Moderate	2	657,936	-610	-37,802	619,524	-5.8
	Low	1	0	0	83,653	83,653	NA
	Nil	0	0	0	1,704	3,081	NA
	No Rating		2,583	0	0	2,583	0.0
	Total		**982,738**	**-1,378**	**1,704**	**984,441**	**-5.8**

14.2.1.5.2 Mine and Winter Roads

Residual effects are limited to the mine portion of the Project. After mitigation, the Kiggavik mine site will result in a direct loss of 1,378 ha of previously usable peregrine falcon habitat. The Project is anticipated to reduce the availability of high and moderate quality habitat by 75.0% and 46.9%, respectively, within the LAA; and by 4.9% and 2.1%, respectively, within the RAA (Table 14.2-3). This equates to an overall reduction of 39.3% habitat units within the LAA and 2.1% habitat units within the RAA.

Table 14.2-3 Peregrine Falcon Habitat Baseline and Predicted Effects for the Mine Site and Winter Road Options

Area	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effects	
	Class	Value	ha	ha	ha	ha	%
LAA	High	3	20,151	-768	-14,345	5,039	-75.0
	Moderate	2	24,858	-610	-11,056	13,192	-46.9
	Low	1	0	0	25,401	25,401	NA
	Nil	0	0	0	0	1,378	NA
	No Rating		0	0	0	0	NA
	Total		45,009	-1,378	0	45,009	-39.3
RAA	High	3	322,218	-768	-15,007	306,444	-4.9
	Moderate	2	657,936	-610	-13,394	643,932	-2.1
	Low	1	0	0	28,401	28,401	NA
	Nil	0	0	0	0	1,378	NA
	No Rating		2,583	0	0	2,583	0.0
	Total		**982,738**	**-1,378**	**0**	**982,738**	**-2.1**

14.2.1.6 Determination of Significance for Change in Habitat Availability for Raptors

The effect of the Project on raptor habitat within the RAA is assessed as not significant. The magnitude of the residual effects caused by the Project on raptor habitat availability is rated as low during all Project phases and for all road options. The Project is expected to result in a detectable loss of habitat within the RAA. The loss of habitat will be biologically not significant because all raptors will continue to have abundant suitable habitat available for foraging.

The effect will occur regularly during each growing season throughout the life of the Project. Given the size of the expected ZOI, effects are expected to be confined within the LAA. The loss of habitat is reversible as prey species will likely use reclaimed areas. The road option that will have the greatest effect on raptor habitat is the North All-Season Road because of the larger Project footprint, and the activities on that road during the breeding season. The effect of the mine with the North All-Season Road is predicted to result in a not significant loss of 5.8% of available raptor habitat.

Legend

- Water
- Mine/North All-Season Road LAA
- Regional Assessment Area

Peregrine Habitat Suitability Growing Season (Post Development)

- High
- Moderate
- Low
- Nil
- No Rating

Area of Detail

Nunavut

N

Schultz Lake

Qamanaajuk Lake

Whitehills Lake

Skinny Lake

Siamese Lake

Long Lake

Thelon River

Aberdeen Lake

Thom Lake

Baker Lake

Judge Sissons Lake

Audra Lake

Pitz Lake

Princess Mary Lake

Mallery Lake

0 2.5 5 10 15 20 Kilometers

500000 520000 540000 560000 580000 600000 620000 640000 660000 680000

7180000 7160000 7140000 7120000 7100000 7080000

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/05/2011 Scale: 1:500,000
File: 14.2-1_Habitat_Suitability_Growing_PD_Peregrine.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 14.2-1
POST-DEVELOPMENT PEREGRINE HABITAT SUITABILITY - GROWING SEASON
MINE AND NORTH ALL-SEASON ROAD

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project

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14.2.1.7 Summary of Project Residual Environmental Effects for Change in Habitat Availability

Table 14.2-4 summarizes the residual effects of the Project on change in raptor habitat availability. The confidence in the prediction is rated as moderate because there is some uncertainty in the exact size of the ZOI, relative habitat quality ratings, and how disturbance will change raptor foraging behaviour.

14.2.1.8 Compliance and Environmental Monitoring for Change in Habitat Availability

The extent of the Project footprint will be monitored on an annual basis to confirm habitat loss predictions.

14.2.2 Assessment of Project Residual Effects for Change in Nest Productivity

The raptor indicator species is peregrine falcon. One measurable parameter for raptors is the overall productivity of nest sites (territories) currently known to exist within the RAA (summarized in Tier 3, Appendix 6C). Project activities could potentially reduce nest site (territory) productivity through changes in adult activity budgets (reduced foraging time) and nest abandonment.

14.2.2.1 Analytical Methods for Change in Nest Productivity

Nest productivity is considered as the capability of mating peregrine falcon pairs to produce an average of 1.25 chicks/year. The assessment is limited to the mine and North All-Season Road LAA because 1) raptor nest surveys have been limited to this area, and 2) potential Project effects will be limited to the LAA region. It is unknown what the baseline long-term productivity rate is for historic nesting locations within the LAAs. Long-term trends from a peregrine falcon monitoring program in Rankin Inlet Nunavut show productivity rates of 1.15 ± 0.62 chicks from 1982 to 2009 (Franke et al. 2010). Further investigation of the Kiggavik nests is required to fully address potential effects. Baseline productivity data can be enhanced during the pre-construction phase.

The effects assessment is based on a breeding territory basis for the following reasons: 1) the limited numbers of sites (nine) found to date; 2) peregrine falcons are philopatric and return to the same nesting territory for many years, and territories are often occupied over many generations; and 3) the relative ease of follow-up monitoring. The assessment is for the North All-season Road option only because the winter road options do not interact with breeding peregrine falcons.

Table 14.2-4 Summary of Project Residual Environmental Effects for Change in Habitat Availability for Raptors

Project Phase	Mitigation / Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in Raptor Habitat — North All-Season Road Option												
Construction Operation	progressive reclamation; Project footprint; dust suppression	N	L	L	MT	R	R	U	N	N/A	M	None required
Change in Raptor Habitat — South and North Winter Road Options												
Construction Operation	progressive reclamation; Project footprint; dust suppression; winter road; tailings management	N	L	L	MT	R	R	U	N	N/A	M	None required

Table 14.2-4 Summary of Project Residual Environmental Effects for Change in Habitat Availability (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible: No anticipated effect on wildlife species

L Low: Observable effect on wildlife species but not likely to affect the species' sustainability in the Project area

M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the region

H High: Population-level detectable change to habitat availability, productivity and health of the Peregrine Falcon *tundrius* population

Geographic Extent:

S Site-specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities

14.2.2.2 Baseline Conditions for Change in Nest Productivity

There are nine known nest sites that have been active in the RAA (not all have been occupied in the same year; Table 14.2-5, Table 14.2-6; Tier 3, Appendix 6C). Surveys were focused on these nests, all of which were located within the North All-Season Road (Figure 14.2-2). To avoid disturbance of nesting falcons, nest area productivity was not monitored consistently during baseline studies (e.g., determining territory occupancy, eggs laid, eggs hatched, chicks fledged; Postupulsky 1974; Court et al. 1988; Table 14.2-5).

Table 14.2-5 Peregrine Falcon Nest Productivity in the RAA

Species and Measures	2009	2008	1980[a]	1979[b]
Total active nests	8	6	6	3
Average clutch size	3.5	3.2	5 (n=5)	3.6
% hatched / % fledged	ND/ND	ND/ND	ND/58	ND/ND

NOTES:
[a] URG 1981
[b] Speller et al. 1979; ND = No data; N/A = Not applicable

Table 14.2-6 Summary of Raptor Nests in the Mine Local Study Area and along the North All-Season Road (2008–2009)

Nest	Species in 2008	Species in 2009	Eggs in 2008	Eggs in 2009	Comments in 2008 and 2009
RN1	PEFA	PEFA	3	3	2008 — Territorial pair 2009 — Nest moved 30 m to SE. Three chicks on August 2
RN2	PEFA	PEFA	4	4	2008 — Territorial pair 2009 — Female on territory; no chicks or eggs on July 30
RN3	PEFA	PEFA	ND	3	2008 — Incubating female 2009 — Female on territory; no birds, chicks or eggs on July 30
RN4	PEFA	INACTIVE	3	N/A	2009 — Pair moved to site RN5; No birds, chicks or eggs on July 30
RN5	RLHA	PEFA	3	4	2009 — Three eggs observed 18 June and four at later date; No birds, chicks or eggs on July 30
RN8	PEFA	PEFA	3	0	2008 — Three eggs 2009 — Territorial pair, predated nest
RN9	PEFA	PEFA	3	4	2009 — Nest site moved 105 m SE on same cliff. No eggs or chicks
RN10	N/A	INACTIVE	N/A	N/A	2009 — Abandoned stick nest

Table 14.2-6 Summary of Raptor Nests in the Mine Local Study Area and along the North All-Season Road (2008–2009) (cont'd)

Nest	Species in 2008	Species in 2009	Eggs in 2008	Eggs in 2009	Comments in 2008 and 2009
RN11	N/A	PEFA	N/A	3	2009 — Two chicks and two actively defending adults on July 30th
RN12	N/A	INACTIVE	N/A	N/A	2009 — Large stick nest, no eggs.
RN13	N/A	INACTIVE	N/A	N/A	2009 — Old large stick nest, no eggs.
RN14	N/A	INACTIVE	N/A	N/A	2009 — Abandoned stick nest
RN15	N/A	PEFA	N/A	ND	2009 — Territorial pair, nest not located
NOTES: PEFA = Peregrine Falcon, RLHA = Rough-legged Hawk ND = No data; N/A = Not applicable					

14.2.2.3 Effect Mechanisms and Linkages for Change in Nest Productivity

Continued exploration activities, construction, and operations have the potential to interact negatively with peregrine falcons. Continued aircraft use at the site has the potential to disturb peregrine falcons. Nesting peregrine falcons show individual and seasonal variation in response to small fixed-wing aircraft and helicopter overflights (Ritchie 1987). The degree of response to disturbance is associated with the stage of the breeding season. Adults were least likely to respond during incubation and most likely to respond during post-brooding and fledging. Aircraft (fixed-wing and helicopter) flown along the Alaska pipeline corridor 1,066 to 1,585 m from the eyries (nest sites) did not cause a disturbance response. In Arizona, nesting peregrine falcon reaction to military overflights were initially alarm or alert responses but returned to normal activity within a few seconds after the disturbance (Ellis et al. 1991). Nesting peregrines also appear to be less disturbed by the high-frequency whine made by some jet engine helicopters than by low-frequency noise of piston-powered helicopters (White and Sherrod 1973).

Road construction and traffic may have an effect on nesting behaviour, although most research associates disturbances with highway traffic. Highway development can have adverse and beneficial effects on raptor populations (Postovit and Postovit 1987). Additional to habitat modification and increased human disturbance, peregrine falcons have collided with road traffic (Williams and Colson 1987). Detrimental effects include habitat loss/modification for some raptors, and stress due to increased human disturbance. There are no studies of raptor response to roads similar to the Project's proposed North All-Season Road.

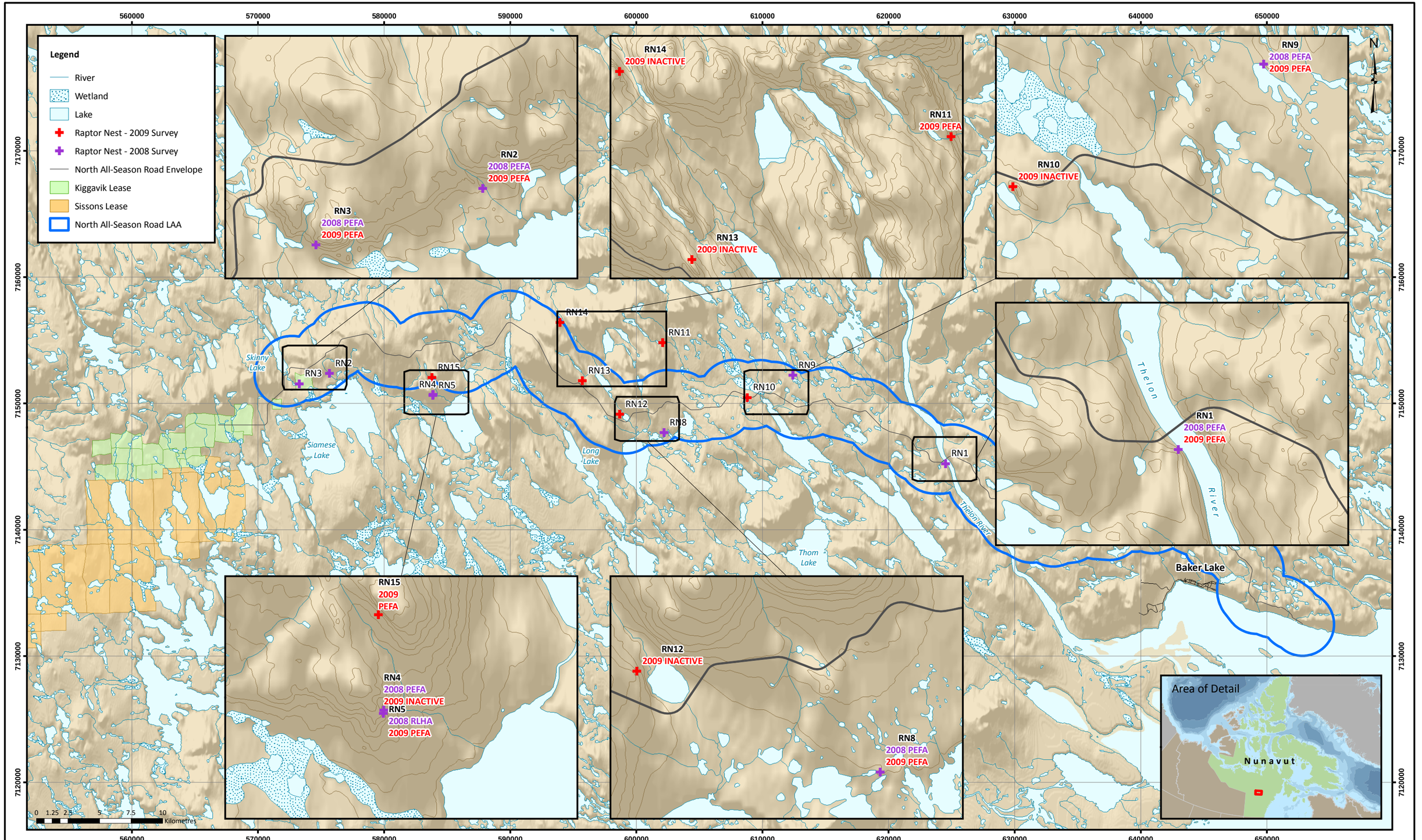
Mining-related disturbances are generally similar to any relatively permanent and continuous disturbance at a raptor site. In one of the few controlled studies, White and Thurow (1985) found that undisturbed ferruginous hawk (*Buteo jamaicensis)* nests fledged an average of one young more than nests exposed to experimental disturbance (the disturbance was composed of noise, vehicle, and human activity). Disturbed adult birds deserted their nest approximately 30% of the time. A one-year correlational study of two areas, one of which was subject to industrial blasting during mining operations, found that the mined area supported fewer raptors (Bednarz 1984). Unfortunately, the reason for the difference was not further investigated. Interestingly, White and Thurow (1985) reported peregrine falcon and golden eagle (*Aquila chrysaetos*) raised young only a few hundred metres from areas where mining and blasting occurred.

Specific to the Project, there are several nest sites that are located near the proposed North All-Season Road (RN12, RN13, RN10, and RN1). These will be the key nest sites for follow-up monitoring if the North All-Season Road becomes the final option for the Project.

14.2.2.4 Mitigation Measures and Project Design for Change in Nest Productivity

Ontario is the only known jurisdiction to have completed a set of management guidelines for peregrine falcon (OMNR 1987). Given the long-term use of peregrine falcon eyries, a key recommendation of the document is that a nest-specific management plan be prepared for each nest within a 3 km radius. A management plan describing buffer zones above (overflights) and horizontal to (ground disturbance) the nest site, restrictions within the buffer zones and scheduling of activities should be prepared for each nest site. A site-specific management plan allows buffers to be varied based on topography, line-of-site, bird response, and history of disturbances at a nest site.

If a pair of nesting falcons is established at an eyrie, the OMNR guidelines suggest that efforts be made to identify hunting areas (e.g., lakes, wetlands). That information can be used to assess the effects of habitat alteration on the prey base. As long as the prey habitat is left undisturbed, it may be possible to change some components of the habitat without affecting the productivity of nesting peregrine falcons.



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/05/2011 Scale: 1:275,000
File: 14.2-2_Raptor_Nests_N_All-Season.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 14.2-2
RAPTOR NESTS ALONG THE
NORTH ALL-SEASON ROAD

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Nest ID	Zone	UTM East	UTM North
RN1	14	624528.0	7145239.0
RN2	14	575671.0	7152388.0
RN3	14	573268.0	7151576.0
RN4	14	583888.0	7150707.0
RN5	14	583880.0	7150656.0
RN8	14	602197.0	7147702.0
RN9	14	612423.0	7152240.0

Nest ID	Zone	UTM East	UTM North
RN10	14	608808.7	7150480.5
RN11	14	602088.0	7154826.5
RN12	14	598685.8	7149153.6
RN13	14	595733.0	7151818.2
RN14	14	593964.3	7156418.7
RN15	14	583809.5	7152076.2

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Key mitigation for ensuring continued productive nesting in the LAA includes:

Construction Period – Nesting pairs are most likely to be disturbed during Project construction if the North All-Season Road is constructed. Key mitigation measures include the following during the construction period:

- Blasting activities (for road construction) within 3 km of a known nest site will occur outside of the territory occupancy and nesting season (~ mid-May through to end of August).
- Land-based activities within a 3 km radius of active nest sites will be restricted during the nesting season.
- Nest site-specific construction mitigation plan will be developed and will include territory activity monitoring when construction is occurring within 3 km of a known nest site.

Operation – The bulk of the disturbance to nesting pairs is expected to have occurred during the construction period. Mitigation during operations can include:

- no on-ground visits to active nest sites by Kiggavik employees
- no overflights of known nest sites

14.2.2.5 Residual Effects for Change in Nest Productivity

14.2.2.5.1 Mine and North All-Season Road

Project residual effects on peregrine falcon productivity will be limited to those nests closest to the North All-Season Road. Most of the disturbance will occur during the construction period.

14.2.2.5.2 Mine and Winter Roads

Winter road construction and operation will not interact with nesting peregrine falcons. Effects of the winter road options are limited to the mine portion of the Project, but nests are not known to occur in this area.

14.2.2.6 Determination of Significance for Change in Nest Productivity

The effect of the Project on change in raptor nest productivity is assessed as not significant, since the Project footprint does not interact with known raptor nest sites and reduced disturbance at nest sites during the breeding season should reduce the potential for adverse effects on raptor nest productivity. The expected magnitude of Project effects is rated as moderate during construction, low during operation, and negligible for all other Project phases.

Project residual effects on peregrine falcon productivity will be limited to those nests closest to the North All-Season Road and entirely within the LAA. Most of the disturbance will occur during the construction period. During mine operations, very few or no raptors will be exposed to substantial enough disturbance that the productivity of their nest will be affected. Effects will last for the duration of the Project, but will be reversible and will return to baseline conditions upon Project completion.

14.2.2.7 Summary of Project Residual Environmental Effects on Nest Productivity

Table 14.2-7 summarizes the residual environmental effects for change in raptor nest productivity. The only nests that have been found within the RAA are those near the North All-Season Road option. The North Winter Road and South Winter Road are not anticipated to affect peregrine falcon productivity. Confidence in this prediction during the construction and operation phase is moderate. Final engineering details on road construction are not specific enough to determine specific disturbances to nests closest to the road alignment.

14.2.2.8 Compliance and Environmental Monitoring for Change in Nest Productivity

Monitoring for change in raptor nest productivity will include:

- Individual nest site monitoring during construction to determine when breeding pairs are attempting to establish a territory and select a nesting location; and,
- Annual monitoring of territory occupancy, egg laying, egg hatching, and chick fledging (i.e., productivity) of all nests identified (i.e., both historic and new nesting locations).

Table 14.2-7 Summary of Residual Environmental Effects for Change in Nest Productivity

Project Phase	Mitigation / Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in Peregrine Falcon Productivity — North All-Season Road Option												
Construction	Blasting outside of breeding window.	N	M	L	MT	S	R	U	N	N/A	M	Individual nest site monitoring during construction. Annual productivity monitoring.
Operation	No disturbance at nest site policy. No overflights.	N	L	L	MT	C	R	U	N	N/A	H	Annual productivity monitoring

Table 14.2-7 Summary of Project Residual Environmental Effects for Change in Nest Productivity (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible: No anticipated effect on wildlife species.

L Low: Observable effect on wildlife species but not likely to affect the species' sustainability in the Project area.

M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the region.

H High: Population-level detectable change to habitat availability, productivity and health of the Peregrine Falcon *tundrius* population

Geographic Extent:

S Site-specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities.

14.2.3 Assessment of Change in Health

Emissions from the Project have the potential to expose raptors to COPC. The potential for these emissions to affect peregrine falcons was evaluated.

14.2.3.1 Analytical Methods for Change in Health

Emissions from the Project can affect the concentrations of COPC in the environment (e.g., water, soil, small mammals), which in turn can potentially affect raptors. The COPC included in this assessment were uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, and zinc.

Peregrine falcons prey almost exclusively on birds but will also eat small mammals such as rodents and squirrels. To estimate potential exposure to falcons, COPC concentrations in prey was evaluated. Detailed air quality modelling (discussed in Volume 4) and water quality modelling (discussed in Volume 5) were used as inputs to the environmental pathways assessment. The concentrations in prey (e.g., songbirds) were predicted by using transfer factors that relate the concentration in different components (e.g., plant-to-bird). The transfer factors are based on site-specific information (where possible), augmented by published data. The intake of COPC through the diet of birds and small mammals is then multiplied by a separate transfer factor to obtain a concentration within the animal. This concentration is used for the prey of the falcon.

The intake of COPC can be estimated using the predicted concentrations and assumptions regarding how much a peregrine falcon consumes. The duration of time a raptor spends in the area is also an important factor. For peregrine falcon, it is assumed that individuals would be present for four months within the LAA and RAAs. The estimated intakes are compared to benchmarks that are considered safe for avian species. For estimating radionuclide dose, the concentration of each radionuclide is estimated from the calculated intake in the same manner as discussed for the prey species. Dose coefficients are used to estimate the dose from each radionuclide based on the concentration. Radiation effects on biota depend not only on the absorbed dose, but also on the relative biological effectiveness (RBE) of the particular radiation (i.e., alpha, beta or gamma radiation). Recent recommendations have focused on an RBE of 10 for alpha radiation; however, to illustrate the effects of uncertainty in RBE, a range was examined. The total dose (which is based on the baseline plus Project emissions for the sum of the uranium-series radionuclides) is compared to a benchmark that is considered protective of avian species (1 mGy/d).

The bounding scenario carried through the ecological assessment was based on separate discharges from the Kiggavik WTP and Sissons WTP, an extended operating period (25 years) followed by a 22-year period of consolidation where water treatment would be required. The assessment accounted for the uncertainty and variability in the emissions and the behaviour in the environment. The details are provided in the Ecological Risk Assessment (Appendix 8A).

14.2.3.2 Baseline Conditions for Change in Health

Under baseline conditions, peregrine falcons are exposed to naturally occurring COPC in the environment. Concentrations of COPC in the tissues of sparrows, lemmings and voles (e.g., prey species) were measured, and this baseline information was used in the pathways assessment.

14.2.3.3 Effect Mechanisms and Linkages for Change in Health

Changes in the health of raptors can occur if they are exposed to COPC at levels that are associated with an effect. As it is important that raptor populations are maintained, the potential for COPC to affect the growth and reproduction of raptors is examined. The assessment of changes in health of raptors depends on the estimated changes in COPC concentrations of environmental components such as vegetation and soil, which are derived from the atmospheric and aquatic environment assessments.

The Project-environment interactions and effects described in the Atmospheric Environment report (Tier 2, Volume 4) and the Aquatic Environment report (Tier 2, Volume 5) form the basis for the effects mechanisms and linkages. The Project air quality effects relate to emissions of dust containing COPC from open pit and underground mining and supporting activities, milling and vehicle traffic on unpaved roads. The Project water quality effects relate to emissions of COPC from WTPs at the Kiggavik and Sissons sites. Complete details about the COPC sources and all assumptions used in the assessments were provided in the atmospheric and aquatic environment assessments.

14.2.3.4 Mitigation Measures and Project Design for Change in Health

Design aspects, operational measures and other mitigation measures have been incorporated into the current Project design, which will reduce Project-associated emissions and/or the potential effect of Project-related emissions.

The Atmospheric Environment report (Tier 2, Volume 4) provides a detailed list of the mitigation measures applied to reduce the changes to ambient air quality. Mitigation measures that have been incorporated to reduce emissions of dust containing COPC include:

- minimizing or reducing vehicle speed on unpaved mine site roads (including pit ramps) and the Kiggavik-Sissons access road and enforce speed limits, where possible
- applying water or another approved dust suppressant to the surfaces of unpaved mine site roads (including pit ramps) and the Kiggavik-Sissons access road, when possible

- maintaining all unpaved road surfaces via grading or other maintenance practices to minimize the amount of silt (i.e., fine particles) present in the roadbed material
- installing appropriate air pollution controls on the exhaust stacks of the mill complex and acid plant (e.g., wet scrubbers, dust collectors) and
- releasing tailings to the TMFs as a slurry below a water surface to avoid tailings dust emissions

The Kiggavik WTP and Sissons WTP have been designed so that the effluent will meet all appropriate regulations such as the MMER as well as site-specific discharge limits. Environmental considerations were paramount in the selection of the appropriate technology for the WTP. Further detail on the design of the WTP can be found in the Project Description report (Tier 2, Volume 2).

14.2.3.5 Residual Effects for Change in Health

In this study, adverse effects from exposure to COPC were characterized by a simple screening index. This index was calculated by dividing the predicted exposure by the toxicity reference value for each ecological receptor as follows:

$$Screening\ Index = \frac{Exposure}{Toxicity\ Reference\ Value}$$

For the wildlife species, the US EPA risk-based ecological soil screening levels (Eco-SSLs) (US EPA 2010) were used as the primary data source for the derivation of toxicity reference values used to determine the potential for an effect. For this assessment, the lowest observable adverse effect levels (LOAELs) based on growth and reproduction are selected because these endpoints are considered to be the most relevant for the maintenance and persistence of wildlife populations.

For COPC without Eco-SSL data (in this case uranium), literature studies were reviewed and values from long-term (chronic) exposure studies were selected. The Eco-SSL database provides information for a number of different species that could be used as a surrogate for other species with similar diets. Some scientific judgement is applied in the selection of the appropriate value, For example, selenium information is available for owls; however since it is one study and much higher than other information, the benchmark value for a black-crowned night heron was used as the surrogate for the falcon. If none of the test species were similar to the ecological receptors selected in this assessment, then the lowest value was selected as the conservative default benchmark for the ecological receptor. Appendix 8A of Tier 3 provides the final selected values along with additional detail on the derivation and rationale for the value.

Screening index values are not estimates of the probability of ecological effect. Rather, the index values are correlated with the potential for an effect, (e.g., higher index values imply a greater potential for an effect). The estimated exposure of the peregrine falcon includes both the natural baseline levels as well as the effect of the Project emissions. Therefore, a screening index value less than 1.0 indicates that the estimated total exposure is less than the threshold that is associated with a potential effect. The screening index values for peregrine falcon for are shown in Table 14.2-8.

Table 14.2-8 Screening Index Values for Peregrine Falcon

COPC	Screening Index (SI)		
	Baseline	Falcon Present in the LAA	Falcon Present in the RAA
Arsenic	0.001	0.001	0.001
Cadmium	0.001	0.002	0.001
Cobalt	<0.001	<0.001	<0.001
Copper	0.003	0.003	0.003
Lead	0.001	0.001	0.001
Molybdenum	<0.001	<0.001	<0.001
Nickel	0.001	0.002	0.001
Selenium	0.17	0.172	0.171
Uranium	<0.001	<0.001	<0.001
Zinc	0.043	0.043	0.043
Radioactivity	0.05	0.05	0.05

NOTES:

SI values for non-radiological COPC are based on the maximum mean exposure compared to a LOAEL (lowest observed adverse effects level)

SI values of radiological effects include the contribution from U-238, Th-230, Ra-226, Pb-210 and Po-210, using an RBE of 40 and compared to a benchmark of 1 mGy/d

Details of calculation as well as additional results provided in Tier 3, Appendix 8A

14.2.3.6 Determination of Significance for Change in Health

As the level of exposure for peregrine falcon is not expected to change from baseline and the exposure will remain below exposure levels associated with adverse effects, no residual or significant effects are expected on the health of raptors.

14.2.3.7 Compliance and Environmental Monitoring for Change in Health

No specific monitoring requirements are recommended based on the assessment for change in health of raptors because there are no predicted measurable effects on raptor health.

14.3 CUMULATIVE EFFECTS ANALYSIS FOR RAPTORS

14.3.1 Screening for Cumulative Environmental Effects

Residual effects on raptor habitat are related to foraging areas, and are more directly related to songbird habitat. Cumulative effects on songbird habitat are addressed in Section 15.3.

The Project will not result in a measurable or reasonably expected residual environmental effect on peregrine falcon nest productivity. The effects of the Project on peregrine falcon populations will not be detectable on the species' overall population. In combination with a not significant effect on migratory bird habitat, peregrine falcons are expected to continue productively nesting in the RAA. Consequently, no cumulative environmental effects on raptor productivity are expected.

There are no expected residual effects on raptor health and health is not considered further for cumulative effects.

14.4 SUMMARY OF RESIDUAL EFFECTS ON RAPTORS

14.4.1 Project Effects

The residual Project effects on peregrine falcon habitat availability, nest productivity, and health are assessed as not significant. Reduced habitat availability caused by the Project is expected to be confined within the mine site and North All-Season Road LAA. Nesting peregrine falcons are only expected to interact with the Project along the North All-Season Road, so productivity is expected to remain unchanged after the construction phase. During construction, when most activity will occur along the road, some peregrine falcon nests could potentially have reduced productivity. No residual effects on peregrine falcon health are anticipated because of exposure the COPCs.

14.4.2 Cumulative Effects

The Project is not anticipated to act cumulatively with other projects to cause a significant reduction of habitat availability within the Kivalliq region. The effects on nest productivity and health will be undetectable, and those effects are not expected to act in combination with any other Project-specific effects. Changes in habitat availability are related to availability of prey species, therefore, the effects of the Project are dependent on the effects to songbird habitat. Cumulative effects on songbird habitat are addressed in Section 15.3.

14.4.3 Effects of Climate Change on Raptors and Habitat

Cumulative effects of climate change on raptors and habitat are expected to be negligible within the 20 to 30 year lifespan of the mine. If peregrine falcons are affected by climate change, it will occur via indirect effects. A study in nearby Rankin Inlet, Nunavut, found a strong correlation between the highly variable breeding success of peregrine falcons and weather, especially summer rainfall and spring snow storms (Bradley et al. 2005). With increased variability in seasonal weather conditions, the long-term reproductive success of peregrine falcons could potentially be compromised. However, this mechanism is expected to occur independently from the Project, and is not expected to act in combination with any other Project-specific effects.

14.5 SUMMARY OF MITIGATION MEASURES FOR RAPTORS

The winter road options are key Project design features that will mitigate many of the Project potential effects on raptors and their habitat. Minimizing the Project footprint will reduce the overall loss of available habitat. Other AREVA environmental policies and mitigation measures that will reduce potential Project effects on raptors include:

- a policy on wildlife harassment, including no disturbance at raptor nest sites
- minimizing the Project footprint
- minimizing Project activities outside of the footprint
- progressively reclaiming disturbed areas
- providing dust suppression along roads during dry summer periods
- eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings
- restricting blasting activities (for road construction) will occur outside of the territory occupancy and nesting season (around mid-May through to end of August) when blasting needs to occur within 3 km of a nest site
- restricting land-based activities within a 3 km radius of active nest sites
- developing a nest site-specific construction mitigation plan, which will include territory activity monitoring when construction is occurring within 3 km of a known nest site. This can allow operations to be modified should the breeding raptors show adverse reaction to nearby disturbances.
- reducing the risk of abandonment by prohibiting on-ground visits to active nest sites by Kiggavik employees
- reducing the risk of abandonment by prohibiting overflights of known nest sites during the breeding season

14.6 SUMMARY OF COMPLIANCE AND ENVIRONMENTAL MONITORING FOR RAPTORS

The extent of the Project footprint will be monitored on an annual basis to confirm habitat loss predictions.

15 EFFECTS ASSESSMENT FOR MIGRATORY BIRDS

15.1 SCOPE OF THE ASSESSMENT FOR MIGRATORY BIRDS

The migratory bird effects assessment focuses on the indicator species lapland longspur and long-tailed duck. Other birds that occur within the RAA either occur at low densities and a change from baseline condition would be undetectable or environmental effects linked to the indicator species (along with proposed mitigation measures) would also reduce the potential for other migratory birds to be affected by the Project.

15.1.1 Project-Environment Interactions and Effects

Key issues for migratory birds include Project-related effects on habitat availability and health. Project components related to these potential effects include site clearing (habitat loss), mine operation (reduced habitat effectiveness), road construction (habitat loss) and operation (reduced habitat effectiveness), milling (noise affecting habitat effectiveness and dust affecting forage and ultimately bird health). Project activities that could affect migratory birds are outlined in Table 15.1-1.

Table 15.1-1 Project-Environment Interactions and Effects on Migratory Birds

Project Component	Project Activities	Lapland longspur		Long-tailed duck	
		Change in Habitat Availability	Change in Health	Change in Habitat Availability	Change in Health
Construction					
In-Water Construction	Construct freshwater diversions and site drainage containment systems (dykes, berms, collection ponds)			✓	
	Construct in-water/shoreline structures			✓	
On-Land Construction	Site clearing and pad construction (blasting, earth moving, loading, hauling, dumping, crushing	✓		✓	
Supporting Activities	Transport fuel and construction materials				
	Air transport of personnel and supplies	✓		✓	

Table 15.1-1 Project-Environment Interactions and Effects on Migratory Birds (cont'd)

Project Component	Project Activities	Lapland longspur		Long-tailed duck	
		Change in Habitat Availability	Change in Health	Change in Habitat Availability	Change in Health
Operation					
Mining	Mining ore (blasting, loading, hauling)	✓	✓		✓
Milling	Crushing and grinding		✓		✓
Final Closure					
In-water Decommissioning	Remove in-water/shoreline structures			✓	
On-land Decommissioning	Revegetation	✓		✓	

NOTES:
Only Project interactions ranked as 2 in Table 11.5-1 are carried forward to this table.
A ✓ indicates that an activity is likely to contribute to the effect.

15.1.2 Residual Environmental Effects Criteria for Migratory Birds

Residual effects on migratory birds and habitat were characterized quantitatively and qualitatively using the following six attributes: magnitude/extent, duration, seasonal timing, frequency, and reversibility. Table 15.1-2 provides definitions for these attributes.

Table 15.1-2 Residual Environmental Effects Criteria for Migratory Birds

Attribute	Description	Rating	Definition
Direction	The ultimate long-term trend of the environmental effect	Positive	Increased high quality habitat, or improvements to health relative to baseline conditions
		Neutral	No change in habitat or health from baseline conditions
		Adverse	Reduced amount of high quality habitat, or decrease in health relative to baseline conditions
Magnitude	Amount of change in a measurable parameter relative to baseline conditions	Negligible	No measurable change from baseline condition
		Low	Detectable change to high quality habitat that does not cause a behavioural change in birds, or change in health that affects only up to 10s of individuals
		Moderate	Detectable change in the amount of high quality habitat that could result in a behavioural response of birds, or a change in health in a localized breeding population
		High	A detectable change in high quality habitat across the seasonal range that results in a behavioural change of a population of birds. Health effects detectable within a population of birds.

Table 15.1-2 Residual Environmental Effects Criteria for Migratory Birds (cont'd)

Attribute	Description	Rating	Definition
Geographic Extent	The geographic area within which an environmental effect occurs	Local	Effect confined to the LAA
		Regional	Effect extends beyond the LAA but within the RAA
		Territorial	Effect extends beyond the RAA but within Nunavut
		National	Effect extends beyond Nunavut but within Canada
Frequency	Number of times that an effect may occur over the life of the Project	Once	Effect occurs once
		Sporadically	Effect occurs occasionally but not consistently throughout the life of the Project
		Regularly	Effect occurs at regular intervals throughout the life of the Project
		Continuous	Effect occurs continuously throughout the Project
Duration	Length of time over which the effect is measurable	Short term	Less than one year
		Medium term	More than one year, but not beyond the end of Project decommissioning
		Long term	Beyond the life of the Project
Reversibility	Likelihood that a measurable parameter for a VEC will recover from an environmental effect to baseline conditions	Reversible	Will likely recover to baseline conditions after or before the end of Project decommissioning
		Irreversible	Unlikely to recover to baseline conditions after the end of Project decommissioning

15.1.3 Standards or Thresholds for Determining Significance

In the absence of legislated or otherwise identified thresholds, the significance of effects is determined based on professional judgment. Determination of whether a Project residual effect on migratory birds is not significant is based on whether an effect influences the long-term viability of a population or delays its recovery. A residual effect is considered not significant if the effect causes a change in condition of an individual or group of migratory birds (or their habitat) that is within the range of natural variability or does not affect the integrity of a population in a measurable way.

Habitat —. Based on professional opinion, experience from other northern projects, and knowledge of migratory bird ecology, Project-related effects on habitat availability are considered significant if more than 10% of the habitat units within the RAA are affected.

Health —There are no generic guidelines for Nunavut or Canada that are applicable to assess the effect of changes in biota based on their exposure to COPC. For this assessment, the estimated exposure to COPC by birds is compared to values that are set to be protective of health and if the exposure is lower than this value then no adverse effects are expected. The estimated dose received by the biota from exposure to radioactivity, considering both baseline and Project emissions, is compared to a level that is protective of birds.

15.2 EFFECTS ASSESSMENT FOR MIGRATORY BIRDS

15.2.1 Assessment of Change in Habitat Availability

The Project will result in a loss of habitat for migratory birds during the growing season (e.g., nesting and post-fledging habitat). The Project footprint will make some habitat unavailable for migratory birds, while human activity associated with the Project could cause a functional loss of habitat. Effects on habitat from the Kiggavik Project could act cumulatively with similar effects from other human activities in the area.

The migratory bird indicator species selected were lapland longspur and long-tailed duck. Lapland longspurs are an appropriate indicator species because they are a common migratory upland songbird found throughout the RAA during the growing season. Long-tailed ducks are an appropriate indicator species as they are a common migratory waterbird in the area during the growing season. These two species are suitable indicators of upland songbirds and waterbirds that migrate to the area during the growing season. The measurable parameter for migratory birds is available habitat measured as ELC units.

15.2.1.1 Analytical Methods for Change in Habitat Availability

Habitat within the LAA and RAA was described during the baseline studies by ELC units. ELC units are categorized into high, moderate, low and nil quality habitat for lapland longspur and long-tailed duck (Table 15.2-1). The quality of ELC units will be decreased to nil within the Project footprint, by two categories within 2 km of the footprint and one category reduction at 2-3 km from the Project footprint.

To assess the overall loss of lapland longspur and long-tailed duck habitat availability within the RAA, a habitat unit index is defined. The index is based on assigning a ranked value to each habitat class (e.g., high=3, moderate=2, low=1, nil=0), and summing the available habitat, measured in hectares, weighted by the value of each class. The difference in the weighted sum of available habitat for the baseline conditions, and the predicted direct and indirect loss of habitat indicate the expected loss of lapland longspur and long-tailed duck habitat.

Direct loss of lapland longspur and long-tailed duck habitat is assessed by identifying ELC units that will become unavailable because of the footprint of the mine site and road options. All ELC units within the Project footprint become “nil” quality once the Project is constructed. The winter road options will not affect breeding bird habitat because the habitat will be available again each summer when the road is decommissioned.

Indirect loss of habitat was assessed by reducing habitat quality (ELC unit quality) for the growing season within the mine site and access road options. There was little literature upon which to predict a ZOI of the mine site on migratory bird habitat quality. To predict the effect of the Project on bird habitat, a conservative estimate of the ZOI was chosen. Habitat quality within

the mine site and road ZOIs were reduced by two classes to a minimum of low within 2 km of the mine footprint, and by one class to a minimum of low from 2 to 3 km of the mine footprint. The winter roads do not result in indirect habitat loss because the roads will be decommissioned each year prior to migratory birds arriving in the RAA. Consequently, there will be no human disturbance along the road during the growing season.

Table 15.2-1 Description and Relative Value of ELC Units Migratory Birds during the Growing Season in the RAA

ELC Unit	Long-tailed duck	Lapland longspur
Water	H	L
Sand	M	M
Gravel	M	M
Rock Association	L	M
Wet Graminoid	H	H
Graminoid Tundra	H	H
Graminoid/Shrub Tundra	M	H
Shrub Tundra	L	H
Shrub/Heath Tundra	L	H
Heath Tundra	L	H
Heath Upland	L	H
Heath Upland/Rock Complex	L	M
Lichen Tundra	L	M

NOTES:
1) Growing season is approximately June 1 to September 30 (four months). H = high; M = moderate; L = low
2) Justification of habitat classification is available in Tier 3, Appendix 6C

15.2.1.2 Baseline Conditions for Change in Habitat Availability

Lapland longspurs

Lapland longspurs forage on seeds and insects in diverse habitats, including vegetated and non-vegetated areas. Foraging habitats are most often wet tundra meadows that are relatively flat; however, they will also use drier vegetated slopes. Nesting habitat is usually well-vegetated meadows. Nests are often found sheltered within tussocks of graminoids or mosses, or beneath overhanging shrubs (Hussell and Montgomerie 2002). ELC unit descriptions, ratings and justification are provided in the wildlife baseline report (Tier 3, Appendix 6C).

Long-tailed duck

Long-tailed ducks select nesting sites that are relatively close to waterbodies. Nests are frequently located on islands or on tundra within 100 m from shorelines. Long-tailed ducks forage almost exclusively on or at the edge of waterbodies where they consume primarily aquatic insects, crustaceans, fish roe and vegetation (Robertson and Savard 2002). ELC unit

descriptions, ratings and justification are provided in the wildlife baseline report (Tier 3, Appendix 6C).

15.2.1.3 Effect Mechanisms and Linkages for Change in Habitat Availability

The Project will result in a direct loss of migratory bird habitat because of the Project footprint. Habitat within the Project footprint is expected to provide no usable habitat for migratory birds once the Project is constructed. The Project will also result in an indirect loss of breeding bird habitat because of human disturbance (primarily noise) near the Project footprint. Dust settling on vegetation in habitats adjacent to Project facilities can reduce the quality and quantity of forage. The consequence of noise on migratory birds has been linked to reduced abundance and diversity (Reijnen et al. 1996), and reproductive success (Halfwerk et al. 2011). However, most studies of human effects on birds were conducted in areas of intense human activity, not in a remote arctic environment. Male and Nol (2005) looked at the effects of roads at the Ekati Diamond Mine on lapland longspur reproductive success, finding, no detectable effects on nest site habitat selection or reproductive success. Consequently, the ZOIs used in this assessment are conservative for predicting the potential effects of the Project.

15.2.1.4 Mitigation Measures and Project Design for Change in Habitat Availability

AREVA will mitigate potential adverse effect on migratory bird habitat through:

- minimizing the Project footprint
- minimizing Project activities outside of the footprint
- progressively reclaiming disturbed areas
- providing dust suppression along roads during dry periods
- eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings
- in the case of the winter road options, reducing the Project footprint will mitigate habitat loss and reduce the likelihood of the Project acting cumulatively with other projects in the Kivalliq region

15.2.1.5 Residual Effects for Change in Habitat Availability

15.2.1.5.1 Mine and North All-Season Road

Lapland longspur

The Kiggavik mine site and North All-Season Road will result in a direct loss of 1,704 ha of previously usable habitat (Table 15.2-2). The Project is anticipated to reduce the availability of high quality habitat for lapland longspur by 71.7% within the LAA and 8.6% within the RAA. This equates to an overall reduction of 37.3% habitat units within the LAA and 4.1% habitat units within the RAA (Figure 15.2-1).

Table 15.2-2 Lapland Longspurs Habitat Baseline and Predicted Effects for the Mine Site and North All-Season Road

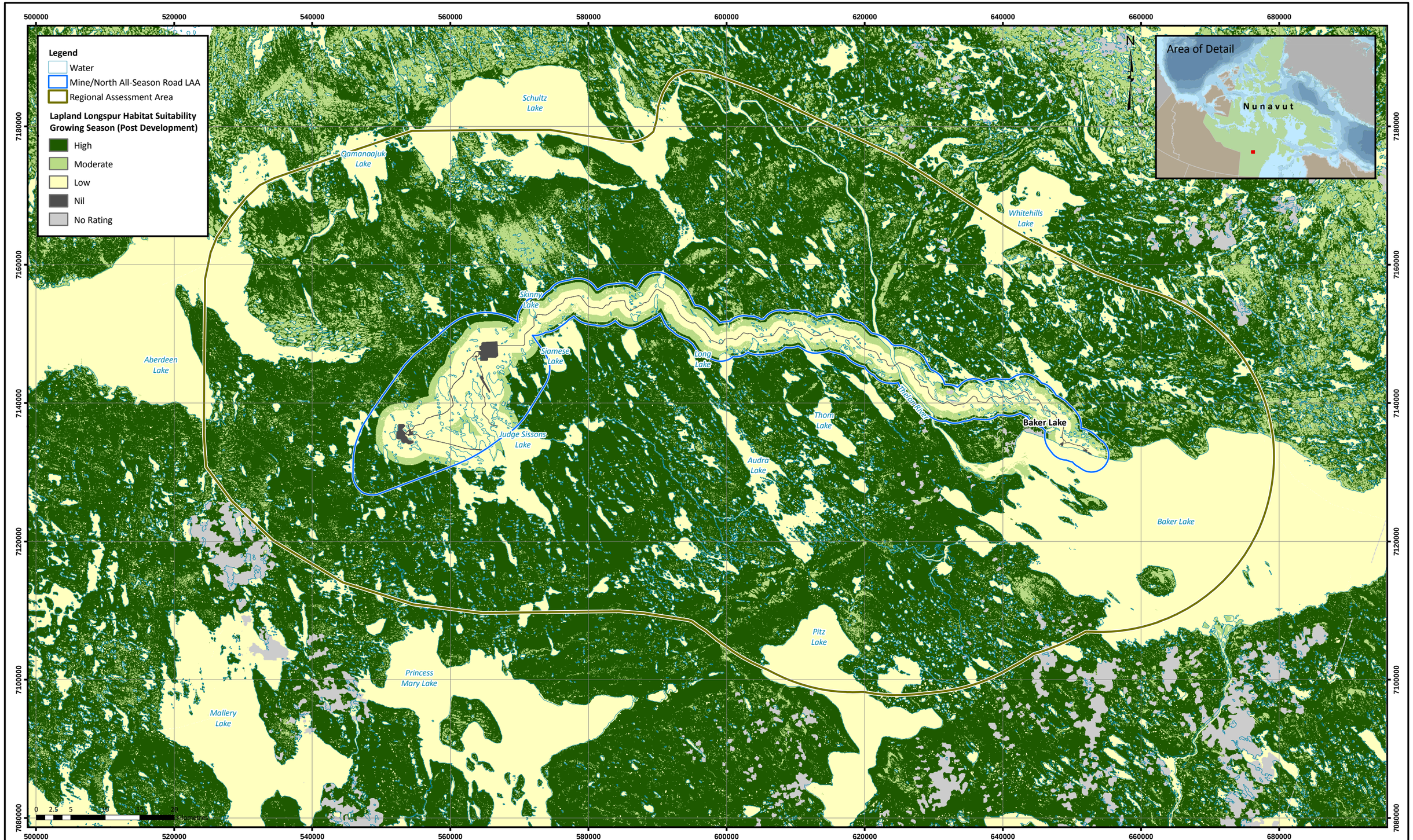
Area	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	
	Class	Value	ha	ha	ha	ha	%
LAA	High	3	76,994	-1,596	-53,638	21,761	-71.7
	Moderate	2	6,031	-84	16,469	22,416	271.7
	Low	1	13,747	-23	37,169	50,893	270.2
	Nil	0	0	0	0	1,704	NA
	No Rating		163	0	0	163	0.0
	Total		96,936	-1,704	0	96,936	-37.3
RAA	High	3	647,737	-1,596	-54,224	591,917	-8.6
	Moderate	2	81,308	-84	16,841	98,064	20.6
	Low	1	251,110	-23	37,383	288,470	14.9
	Nil	0	0	0	0	1,704	NA
	No Rating		2,583	0	0	2,583	0.0
	Total		**982,738**	**-1,704**	**0**	**982,738**	**-4.1**

Long-tailed Duck

The Project is anticipated to reduce the availability of high quality habitat for long-tailed duck by 72.5% within the LAA and 6.1% within the RAA (Table 15.2-3). This equates to an overall reduction of 27.3% habitat units within the LAA and 2.5% habitat units within the RAA (Figure 15.2-2).

Table 15.2-3 Long-tailed Duck Habitat Baseline and Predicted Effects for the Mine Site and North All-Season Road

Area	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	
	Class	Value	ha	ha	ha	ha	%
LAA	High	3	37,239	-331	-26,651	10,257	-72.5
	Moderate	2	7,417	-212	7,138	14,343	93.4
	Low	1	52,124	-1,161	19,513	70,477	35.2
	Nil	0	0	0	0	1,704	NA
	No Rating		155	0	0	155	0.0
	Total		96,936	-1,704	0	96,936	-27.3
RAA	High	3	468,407	-331	-28,246	439,830	-6.1
	Moderate	2	81,521	-212	8,138	89,448	9.7
	Low	1	430,471	-1,161	20,107	449,417	4.4
	Nil	0	0	0	0	1,704	NA
	No Rating		2,339	0	0	2,339	0.0
	Total		**982,738**	**-1,704**	**0**	**982,738**	**-2.5**



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/05/2011 Scale: 1:500,000
File: 15.2-1_Habitat_Suitability_Growing_PD_Lapland.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 15.2-1
POST-DEVELOPMENT LAPLAND LONGSPUR HABITAT SUITABILITY - GROWING SEASON
MINE AND NORTH ALL-SEASON ROAD

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project
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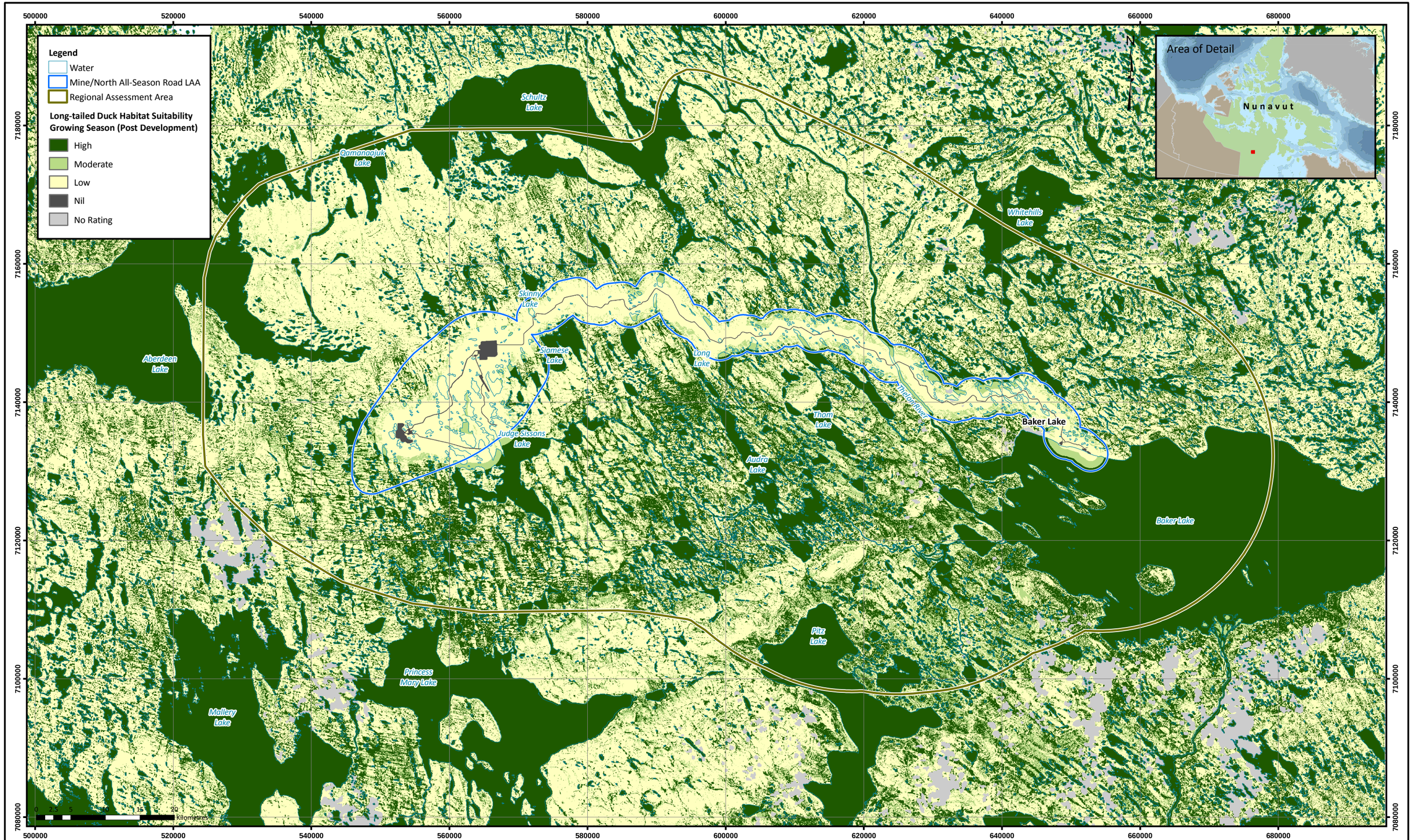


Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/05/2011 Scale: 1:500,000
File: 15.2-2_Habitat_Suitability_Growing_PD_LongTailedDuck.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 15.2-2
POST-DEVELOPMENT LONG-TAILED DUCK HABITAT SUITABILITY - GROWING SEASON
MINE AND NORTH ALL-SEASON ROAD

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project
AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

15.2.1.5.2 Mine and South Winter Road

The South and North Winter roads will not result in a direct or indirect loss of lapland longspur and long-tailed duck habitat. The road will be decommissioned by the time the birds arrive in the area. Residual effects of this Project option are limited to those associated with the mine site.

Lapland Longspur

The Kiggavik mine site will result in a direct loss of 1,378 ha of previously usable habitat (Table 15.2-4). The Project is anticipated to reduce the availability of high quality habitat for lapland longspur by 58.7% within the LAA and 3.5% within the RAA. This equates to an overall reduction of 33.3% habitat units within the LAA and 1.7% habitat units within the RAA.

Table 15.2-4 Lapland Longspurs Habitat Baseline and Predicted Effects for the Mine Site and Winter Road Options

	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	
Area	Class	Value	ha	ha	ha	ha	%
LAA	High	3	37,553	-1,316	-20,711	15,526	-58.7
	Moderate	2	1,377	-40	5,071	6,408	365.5
	Low	1	6,080	-22	15,640	21,697	256.9
	Nil	0	0	0	0	1,378	NA
	No Rating		0	0	0	0	NA
	Total		45,009	-1,378	0	45,009	-33.3
RAA	High	3	647,737	-1,316	-21,204	625,217	-3.5
	Moderate	2	81,308	-40	5,352	86,620	6.5
	Low	1	251,110	-22	15,851	266,939	6.3
	Nil	0	0	0	0	1,378	NA
	No Rating		2,583	0	0	2,583	0.0
	Total		**982,738**	**-1,378**	**0**	**982,738**	**-1.7**

Long-tailed Duck

The Project is anticipated to reduce the availability of high quality habitat for long-tailed duck by 61.8% within the LAA and 2.5% within the RAA (Table 15.2-5). This equates to an overall reduction of 26.1% habitat units within the LAA and 1.2% habitat units within the RAA.

Table 15.2-5 Long-tailed Duck Habitat Baseline and Predicted Effects for the Mine Site and South Winter Road Option

Area	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	
	Class	Value	ha	ha	ha	ha	%
LAA	High	3	16,156	-261	-9,727	6,168	-61.8
	Moderate	2	4,437	-199	178	4,416	-0.5
	Low	1	24,416	-918	9,549	33,047	35.3
	Nil	0	0	0	1,378	2,756	N/A
	No Rating		0	0	0	0	N/A
	Total		45,009	-1,378	1,378	46,387	-26.1
RAA	High	3	468,407	-261	-11,277	456,869	-2.5
	Moderate	2	81,521	-199	1,145	82,466	1.2
	Low	1	430,471	-918	10,133	439,686	2.1
	Nil	0	0	0	1,378	2,756	NA
	No Rating		2,339	0	0	2,339	0.0
	Total		**982,738**	**-1,378**	**1,378**	**984,116**	**-1.2**

15.2.1.6 Determination of Significance for Change in Habitat Availability

The effect of the Project on migratory bird habitat within the RAA is assessed as not significant. Predicted loss of available habitat for migratory birds due to the Project is less than 5% of the habitat units for both indicators and all road options. The magnitude of adverse effects of the Project on migratory bird habitat availability is rated as low during all Project phases and for all road options. The Project is expected to result in a detectable loss of habitat within the LAA. The loss of habitat will be not significant because all migratory birds in the RAA will continue to have abundant suitable habitat available for foraging.

The effect will occur regularly during each growing season for the life of the Project. All effects are expected to be confined within the LAA. The loss of habitat is reversible once operations cease and the disturbed area is reclaimed. The road option that has the greatest effect on breeding bird habitat is the North All-Season Road because of the larger Project footprint and larger ZOI. The confidence in the prediction is rated as moderate because there is some uncertainty in the exact size of the ZOI. Given recent findings at the Ekati Mine, the assessed effects of the Kiggavik Project on migratory birds is likely a conservative estimate.

15.2.1.7 Summary of Project Residual Environmental Effects for Change in Habitat Availability for Migratory Birds

Table 15.2-6 summarizes the residual environmental effects for change in habitat availability for migratory birds.

15.2.1.8 Compliance and Environmental Monitoring for Change in Habitat Availability

The extent of the Project footprint will be monitored on an annual basis to confirm habitat loss predictions.

15.2.2 Assessment of Change in Health

Emissions from the Project have the potential to expose migratory birds (represented by lapland longspur and long-tailed duck) to COPC. The potential for these emissions to cause adverse effects to migratory birds was evaluated.

15.2.2.1 Analytical Methods for Change in Health

Emissions from the Project can affect COPC concentrations in environmental components (e.g., water, soil, aquatic vegetation, insects) which have the potential to interact with migratory birds. The COPC included in the assessment were uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, and zinc.

The lapland longspur is a common songbird that forages on seeds and insects. Long-tailed ducks forage on molluscs and crustaceans at the bottom of lakes (benthic invertebrates) as well as fish. To estimate potential COPC exposure to these birds, the predicted COPC concentration in forage items needs to be considered. Detailed air quality modelling (Tier 2, Volume 4) and water quality modelling (Tier 2, Volume 5) are used as inputs to the environmental pathways assessment. The concentrations in environmental components (e.g., vegetation) are predicted by using transfer factors that relate the concentration in different components (e.g., water-to-fish). The transfer factors are based on site-specific information where possible, augmented by literature data. The Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A) provides a detailed discussion on the selection of transfer factors and how they are applied.

Table 15.2-6 Summary of Project Residual Environmental Effects for Change in Habitat Availability for Migratory Birds

Project Phase	Mitigation / Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in Breeding Bird Habitat — North All-Season Road Option												
Construction	progressive reclamation; Project footprint; dust suppression	N	L	L	MT	R	R	U	N	NA	M	None required
Operation												
Final Closure	None required	N	L	L	MT	R	R	U	N	NA	M	
Change in Breeding Bird Habitat — South and North Winter Road Options												
Construction	progressive reclamation; Project footprint; dust suppression; winter road;	N	L	L	MT	R	R	U	N	NA	M	None required
Operation												
Final Closure	None required	N	L	L	MT	R	R	U	N	NA	M	
Change in Breeding Bird Habitat — South and North Winter Road Options												
Construction	progressive reclamation; Project footprint; dust suppression; winter road	N	L	L	MT	R	R	U	N	NA	M	None required
Operation												
Final Closure	None required	N	L	L	MT	R	R	U	N	NA	M	

Table 15.2-6 Summary of Project Residual Environmental Effects for Change in Habitat Availability (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible No measurable change from baseline condition

L Low: Detectable change to high quality habitat that does not cause a behavioural change in birds, or change in health that affects only up to 10s of individuals.

M Moderate: Detectable change in the amount of high quality habitat that could result in a behavioural response of birds, or a change in health in a localized breeding population.

H High: A detectable change in high quality habitat across the seasonal range that results in a behavioural change of a population of birds. Health effects detectable within a population of birds.

Geographic Extent:

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities.

COPC intake by migratory birds is estimated using the predicted concentrations and assumptions about how much forage the birds consume. The amount of time that wildlife spend in the area is also an important factor. An assumption made for these migratory birds regarding residency time was 4 months (i.e., the snow-free period). It was also assumed that migratory birds that return to the area established territories during the breeding season, and that the birds did not roam outside of these territories during the residency period. The estimated intakes were compared to benchmarks that are protective of avian species. For estimating radionuclide dose, the concentration within the individual of each radionuclide was estimated from the calculated intake through the use of a transfer factor. Dose coefficients were used to estimate the dose from each radionuclide based on the concentration. Radiation effects on biota depend not only on the absorbed dose, but also on the relative biological effectiveness (RBE) of the particular radiation (i.e., alpha, beta or gamma radiation). Recent recommendations have focused on an RBE of 10 for alpha radiation; however, to illustrate the effects of uncertainty in RBE a range was examined. The total dose, which is based on the baseline plus Project emissions for the sum of the uranium-series radionuclides, is compared to a benchmark that is protective of avian species (1 mGy/d).

The scenario carried through the ecological assessment was based on separate discharges from the Kiggavik WTP and Sissons WTP, an extended operating period (25 years) followed by a 22-year period of consolidation where water treatment would be required. The assessment accounted for the uncertainty and variability in the emissions and the behaviour in the environment. The details are provided in the Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A).

15.2.2.2 Baseline Conditions for Change in Health

Under baseline conditions, lapland longspur and long-tailed ducks are exposed to naturally occurring COPC concentrations. COPC concentrations in forage items (e.g., fish, insects) measured during baseline studies were incorporated in the pathways assessment. In addition, measured baseline information from sparrows is used to validate the modelling for lapland longspur.

15.2.2.3 Effect Mechanisms and Linkages for Change in Health

Changes in the health of migratory birds can occur if they are exposed to COPC at levels that are associated with an effect. As it is important that migratory bird populations are maintained, the potential for OPC to affect the growth and reproduction of migratory birds is examined. The assessment of changes in health of migratory birds depends on the estimated changes in COPC concentrations of environmental components such as vegetation, fish and soil, which are derived from the atmospheric and aquatic environment assessments.

The Project-environment interactions and effects described in the Atmospheric Environment report (Tier 2, Volume 4) and Aquatic Environment report (Tier 2, Volume 5) form the basis for the effects mechanisms and linkages. The Project air quality effects relate to emissions of dust

containing COPC from open pit and underground mining and supporting activities, milling and vehicle traffic on unpaved roads. The Project water quality effects relate to emissions of COPC from WTPs at the Kiggavik and Sissons sites. Complete details about the COPC sources and all assumptions used in the assessments were provided in the atmospheric and aquatic environment assessments.

15.2.2.4 Mitigation Measures and Project Design for Change in Health

Design aspects, operational measures and other mitigation measures have been incorporated into the current Project design, which will reduce Project-associated emissions and/or the potential effect of Project-related emissions. These have been discussed in the Atmospheric Environment report (Tier 2, Volume 4) and the Aquatic Environment report (Tier 2, Volume 5) in more detail.

The Atmospheric Environment report (Tier 2, Volume 4) provides a detailed list of the mitigation measures applied to reduce the changes to ambient air quality. Mitigation measures that have been incorporated to reduce emissions of dust containing COPC include:

- minimizing or reducing vehicle speed on unpaved mine site roads (including pit ramps) and the Kiggavik-Sissons access road and enforce speed limits, where possible
- applying water or another approved dust suppressant to the surfaces of unpaved mine site roads (including pit ramps) and the Kiggavik-Sissons access road, when possible
- maintaining all unpaved road surfaces via grading or other maintenance practices to minimize the amount of silt (i.e., fine particles) present in the roadbed material
- installing appropriate air pollution controls on the exhaust stacks of the mill complex and acid plant (e.g., wet scrubbers, dust collectors) and
- releasing tailings to the TMFs as a slurry below a water surface to avoid tailings dust emissions

The Kiggavik WTP and Sissons WTP have been designed so that the effluent will meet all appropriate regulations such as the MMER as well as site-specific discharge limits. Environmental considerations were paramount in the selection of the appropriate technology for the WTP. Further detail on the design of the WTP can be found in the Project Description (Tier 2 Volume 2).

15.2.2.5 Residual Effects for Change in Health

In this study, adverse effects from exposure to COPC were characterized by a simple screening index. This index was calculated by dividing the predicted exposure by the toxicity reference value for each ecological receptor as follows:

$$Screening\ Index = \frac{Exposure}{Toxicity\ Reference\ Value}$$

For the wildlife species, the US EPA risk-based ecological soil screening levels (Eco-SSLs) (US EPA 2010) were used as the primary data source for the derivation of toxicity reference values used to determine the potential for an effect. For this assessment, the lowest observable adverse effect levels (LOAELs) based on growth and reproduction were selected, as these endpoints are the most relevant for the maintenance and persistence of wildlife populations.

For COPC without Eco-SSL data (in this case, uranium), literature studies were reviewed and values from long-term (chronic) exposure studies were selected. The Eco-SSL database provides information for a number of different species that could be used as a surrogate for other species with similar diets. For example, for nickel, the value for a mallard duck is used as the surrogate for the long-tailed duck. If none of the test species were similar to the ecological receptors selected in this assessment, then the lowest value is selected as the conservative default benchmark for the ecological receptor. The Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A) provides the final selected values along with additional detail on the derivation and rationale for the value.

Screening index values are not estimates of the probability of ecological effect. Rather, the index values are correlated with the potential of an effect, e.g., higher index values imply a greater potential of an effect. The estimated exposure of the lapland longspur and the long-tailed duck includes both the natural baseline levels as well as the effect of the Project emissions. Therefore, a screening index value less than 1.0 indicates that the estimated total exposure is less than the threshold level that is associated with a potential adverse effect. The screening index values for the migratory birds are shown in Table 15.2-7.

Emissions from the Project are not anticipated to result in a discernible change in exposure to COPC for these migratory birds. In addition, the results show that it is not expected that the exposure to lapland longspur or long-tailed duck will exceed exposure levels associated with adverse effects.

Table 15.2-7 Screening Index Values for Migratory Birds

COPC	Screening Index (SI)			
	Lapland Longspur		Long-tailed Duck	
	Baseline	Present at Judge Sissons Lake near Discharge Location	Baseline	Present at Judge Sissons Lake near Discharge Location
Arsenic	0.031	0.035	0.016	0.019
Cadmium	0.026	0.029	0.010	0.012
Cobalt	0.006	0.006	<0.001	<0.001
Copper	0.051	0.052	0.039	0.039
Lead	0.009	0.010	0.001	0.001
Molybdenum	0.006	0.007	<0.001	<0.001
Nickel	0.109	0.109	0.008	0.008
Selenium	0.058	0.063	0.041	0.044
Uranium	<0.001	0.003	<0.001	<0.001
Zinc	0.661	0.669	0.136	0.136
Radioactivity	0.05	0.06	0.06	0.06

NOTES:

SI values for non-radiological COPC are based on the maximum mean exposure compared to a LOAEL (lowest observed adverse effects level)

SI values of radiological effects include the contribution from U-238, Th-230, Ra-226, Pb-210 and Po-210, using an RBE of 40 and compared to a benchmark of 1 mGy/d

Details of calculation as well as additional results provided in Tier 3, Appendix 8A

15.2.2.6 Determination of Significance for Change in Health

As the level of exposure for lapland longspur and long-tailed duck are not expected to change from baseline and the exposure will remain below exposure levels associated with adverse effects, no residual or significant effects are expected on the health of migratory birds.

15.2.2.7 Compliance and Environmental Monitoring for Change in Health

No specific monitoring requirements are recommended based on the assessment for change in health of migratory birds. The monitoring of other environmental components (e.g., water, fish, insects) will provide valuable information for confirming the results of the assessment.

15.3 CUMULATIVE EFFECTS ANALYSIS FOR MIGRATORY BIRDS

The effects of other projects and activities have acted cumulatively on the migratory birds and habitat within the RAA during the Base Case and Project Case. The existing conditions described in the Base Case are a result of the effects of past and current projects on wildlife and habitat. The assessment of the Project Case describes the cumulative effects of the Project on the Base Case. This section addresses how environmental effects associated with reasonably foreseeable future projects will interact with the Project Case.

Project construction and operation activities will contribute to loss of available habitat and reduced health. These effects have the potential to act cumulatively during the migratory bird breeding season. The development of the mine, port access, and road access has the potential to increase similar development activity-related disturbances and resulting effects on migratory birds and habitat.

15.3.1 Screening for Cumulative Environmental Effects

Project effects on habitat availability have the potential to act cumulatively with effects from other projects. Residual effects habitat loss/reduced suitability are expected because habitat will be lost beyond the life of the Project to the footprint of the Project and mitigations will only be able to partially mitigate effects of the Project. These effects will be similar to others associated with current and future regional terrestrial development activities that could interact with the Project, and will overlap in time and space. The cumulative effect of a change in habitat availability is assessed.

There are no predicted environmental effects caused by the Project on migratory birds; therefore, they were not considered in the cumulative effects assessment.

15.3.2 Assessment of the Cumulative Effects: Change in Habitat Availability

The Project is not anticipated to result in significant adverse effects on migratory bird habitat within the RAA. Although the residual effects of the Project on changes in habitat availability are not significant, the effects could act cumulatively with similar effects from other human activity in the Kivalliq region that affects migratory bird habitat. The cumulative effect of the habitat loss could reduce the overall availability of habitat for migratory birds in the region to a point that population level effects occur.

15.3.2.1 Effect Mechanisms and Linkages for Cumulative Change in Habitat Availability

The cumulative direct loss of migratory bird habitat will reduce the amount of available habitat regionally, but this effect will not result in measurable or detectable changes in the region. Indirect loss of migratory bird habitat from human disturbance that results in avoidance of use of otherwise suitable habitat may be the largest source of habitat loss. While human disturbance causes a loss of habitat, the effect is temporary as it occurs only while there is human activity.

Current human disturbance within the Kivalliq region that reduces the availability of migratory bird habitat habitat includes:

- Meadowbank Mine — The footprint of the mine and mine access road has reduced the availability of migratory bird habitat during the growing season. Activity at the mine site and transportation to the mine from Baker Lake has indirectly reduced the availability of migratory bird habitat in the area. The Meadowbank Mine is expected to operate until 2019.
- Mineral Exploration Operations — There are numerous mineral deposits being explored in the region. Each of these operations has some amount of human activity (e.g., drilling, surveying). Exploration activities mostly take place during the summer and the footprint of the camps, drill pads and other disturbances is relatively small.
- Local Communities — The footprint of Arviat, Whale Cove, Rankin Inlet, Chesterfield Inlet and Baker Lake reduces the availability of habitat of migratory bird habitat. Sensory disturbance from vehicles, generators, aircraft traffic and other human activities in these communities indirectly reduce the availability of migratory bird habitat.

The Kiggavik Project will add to the overall loss of migratory bird habitat. While there are a number of mineral exploration operations in the region, few exploration projects turn into active mines. Therefore, it is unlikely that the Kiggavik Project will overlap temporally with operating mines or other industrial developments in the region.

15.3.2.2 Mitigation Measures for Cumulative Change in Habitat Availability

Mitigation measures for cumulative changes in habitat availability are the same as those presented for the Project Case. No further actions are necessary to mitigate cumulative effects.

15.3.2.3 Residual Cumulative Change in Habitat Availability

The magnitude of effects of the Project on migratory bird habitat is expected to be negligible. Few projects are expected to overlap temporally with the Kiggavik within the Kivalliq region.

15.3.2.4 Determination of Significance for Cumulative Change in Habitat Availability

Currently, there are few human activities in the region that affect migratory birds. The Meadowbank mine and regional communities are currently the greatest sources of habitat loss for migratory birds. The addition of the Kiggavik Project to these disturbances is not expected to measurably reduce the amount of migratory bird habitat. Mineral exploration is currently not causing significant loss of habitat. Although there is the potential for future mine development in the region, given the history of such development the likelihood of multiple future mines existing at the same time as the Kiggavik Project is low. The cumulative change to habitat availability for migratory birds as a result of the Kiggavik Project is, therefore, assessed as not significant.

There is high confidence in the prediction of a low magnitude cumulative effect on migratory birds and habitat. Lapland longspur and long-tailed duck habitat requirements are generally well understood. There is abundant breeding and foraging habitat for Lapland longspur and long-tailed duck in the Kivalliq region. The species are not at risk, and there were no breeding concentrations or critical habitat components identified within the Kivalliq region that experience cumulative effects associated with the Project. There are few land uses planned in the region that will overlap temporally and spatially with the Kiggavik Project RAA.

15.3.2.5 Compliance and Environmental Monitoring for Cumulative Change in Habitat Availability

Compliance and environmental monitoring for cumulative changes in habitat availability are the same as those presented for the Project Case.

15.3.3 Summary of Residual Cumulative Environmental Effects on Migratory Birds

Table 15.3-1 summarizes the cumulative environmental effects of the Project on migratory birds.

Table 15.3-1 Summary of Residual Cumulative Environmental Effects on Migratory Birds

Cumulative Environmental Effect	Case	Other Projects, Activities and Actions	Mitigation and Compensation Measures	Residual Cumulative Environmental Effects Characteristics							Significance	Prediction Confidence	Likelihood	Proposed Follow-up and Monitoring Programs
				Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Changes in Habitat Availability	Cumulative Effect with Project (Future Case)	Meadowbank Mine, various exploration operations, and various regional communities	Dust management; Minimize Project footprint; Progressive reclamation	N	N	L	LT	C	R	D	N	H	N/A	None
	Project Contribution to Cumulative Effect	NA	NA	N	N	L	LT	C	R	D	N	H	N/A	NA

Table 15.3-1 Summary of Residual Cumulative Environmental Effects on Migratory Birds (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible No measurable change from baseline condition

L Low: Detectable change to high quality habitat that does not cause a behavioural change in birds, or change in health that affects only up to 10s of individuals.

M Moderate: Detectable change in the amount of high quality habitat that could result in a behavioural response of birds, or a change in health in a localized breeding population.

H High: A detectable change in high quality habitat across the seasonal range that results in a behavioural change of a population of birds. Health effects detectable within a population of birds.

Geographic Extent:

S Site-specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities.

15.4 SUMMARY OF RESIDUAL EFFECTS ON MIGRATORY BIRDS AND HABITAT

15.4.1 Project Effects

The Project is expected to result in no significant effects to migratory birds. All effects on migratory birds caused by the Project are rated as low in magnitude, and the effects are anticipated to occur within the LAA. The effects are reversible when the Project enters the closure stage and habitat reclamation is implemented. The confidence in this prediction is moderate.

15.4.2 Cumulative Effects

The contribution of the Project to cumulative effects on migratory birds and habitat are rated as not significant. The Project is expected to have negligible measurable effects on migratory birds and their nesting and foraging habitats in the Kivalliq region. The confidence in this prediction is high.

15.4.3 Effects of Climate Change on Migratory Birds and Habitat

Determining the effects of climate change on migratory birds is complicated due to the contrast of habitats migratory birds use. Winter ranges of migratory birds often extend from southern North America to South America. The expanse of the wintering range introduces an entirely different suite of climate-related effects that are beyond the scope of this assessment. Effects of climate change on migratory birds that seasonally occur within the RAA would likely be related to increased extreme frost or snow events in spring or summer. Indirectly, temporal deviations in environmental conditions (e.g., late snowmelt) could result in increased mortality due to a lack of available forage. An example of this is the diet of the lapland longspur, which consists of the previous season's berries and catkins when they first arrive in the early spring, and arthropods during the summer.

Climate change may alter the tundra vegetation from low-lying shrubs (e.g., berries) to taller deciduous shrubs, benefiting arthropod production resulting in abundant summer forage, but decreasing the production of berries and catkins that are needed when the birds first arrive in the spring (Polar Field Services 2011). These mechanisms are expected to occur independently, and are not expected to act in combination with any other Project effects. Although migratory bird habitat will be lost due to the Project footprint, it is expected that climate change will not act cumulatively with Project effects.

15.5 TRANSBOUNDARY EFFECTS

Project effects are expected to be detectable at the scale of the LAA.

15.6 SUMMARY OF MITIGATION MEASURES FOR MIGRATORY BIRDS

The winter road options are key Project design features that will mitigate many of the Project potential effects on migratory birds. Minimizing the Project footprint will reduce the overall loss of available habitat. AREVA will mitigate potential adverse effects on migratory birds through:

- minimizing Project activities outside of the footprint
- progressively reclaiming disturbed areas
- providing dust suppression along roads during dry summer periods

15.7 SUMMARY OF COMPLIANCE AND ENVIRONMENTAL MONITORING FOR MIGRATORY BIRDS

The extent of the Project footprint will be monitored on an annual basis to confirm habitat loss predictions.

16 EFFECTS ASSESSMENT FOR SPECIES AT RISK

16.1 SCOPE OF THE ASSESSMENT FOR SPECIES AT RISK

The species at risk effects assessment focuses on the indicators Short-eared owl, grizzly bear, and wolverine. Peregrine falcon, the only other wildlife species at risk known to occur within the RAA is an indicator for the effects assessment on raptors (Section 14).

16.1.1 Project-Environment Interactions and Effects

Key issues of concern for species at risk include Project-related effects on habitat availability and health for short-eared owls, as well as grizzly bear and wolverine. Key Project components related to these potential effects include site clearing (habitat loss), mine operation (reduced habitat effectiveness), road construction (habitat loss), operation (reduced habitat effectiveness), and milling (noise and dust and influence on habitat effectiveness and dust effects on forage and ultimately health).

The primary limiting factor affecting short-eared owl is habitat loss and alteration (COSEWIC 2008). Austen et al. (1994) suggested the decline in short-eared owls is mostly related to habitat loss and degradation on its wintering grounds, with continuing habitat loss and degradation on its breeding grounds in southern Canada. Secondary to habitat loss is increased nest depredation by species such as snowy owls, peregrine falcon and great horned owls (Clark 1975). Nest depredation has been increasing as a result of habitat fragmentation (Johnson and Temple 1986; COSEWIC 2008). Declines in prey abundance (as a result of changes in habitat), collisions with vehicles, utility lines and barbed wire fences, and to a lesser degree effects due to pesticide and contaminants are also factors in the decline of short-eared owl (COSEWIC,2008).

Grizzly bear mortality has been identified as the primary threat to grizzly bear populations in North America (Ross, 2002). Wolverine populations in Canada are threatened by a combination of factors that are thought to be causing a decline of wolverines across their ranges, and no primary population limiting issue has been identified. Threats to the wolverine population are habitat loss, direct mortality, loss of primary food sources (e.g., caribou) and food providers (e.g., wolves), and disturbance at denning sites (COSEWIC 2003).

A potential Project effect to both grizzly bear and wolverine (and other scavengers such as gulls) is attraction to garbage. This was not assessed for this Project because garbage and waste management will follow best management practices and attraction is unlikely.

Some of the key Project activities that could affect species at risk are outlined in Table 16.1-1.

Table 16.1-1 Project-Environment Interactions and Effects on Species at Risk

Project Component	Project Activities	Environmental Effects		
		Short-eared owl		Grizzly Bear and Wolverine
		Change in Habitat	Change in Health	Change in Health
Construction				
On-Land Construction	Site clearing and pad construction (blasting, earth moving, loading, hauling, dumping, crushing	✓		
Supporting Activities	Transport fuel and construction materials	✓		
	Air transport of personnel and supplies	✓		
	Explosives storage and use	✓	✓	✓
Operation				
Mining	Mining ore (blasting, loading, hauling)	✓	✓	✓
Milling	Crushing and grinding		✓	✓
Final Closure				
On-land Decommissioning	Revegetation	✓		

NOTES:
Only Project interactions ranked as 2 in Table 11.5-1 are carried forward to this table.
A ✓ indicates that an activity is likely to contribute to the effect.

16.1.2 Residual Environmental Effects Criteria for Species at Risk

Residual effects on species at risk were characterized quantitatively and qualitatively using the following six attributes: magnitude/extent, duration, seasonal timing, frequency, and reversibility. Table 16.1-2 provides definitions for these attributes.

Table 16.1-2 Residual Environmental Effects Criteria for Species at Risk

Attribute	Description	Rating	Definition
Direction	The ultimate long-term trend of the environmental effect	Positive	Increased habitat availability (nesting and foraging) or improvements to health relative to baseline conditions
		Neutral	No change in habitat availability or health
		Adverse	Reduced habitat availability or health
Magnitude	Amount of change in a measurable parameter relative to baseline conditions	Negligible	No measurable changes anticipated effect on wildlife species.
		Low	Observable effect on wildlife species but not likely to affect the species' sustainability in the LAA.
		Moderate	Observable effect on wildlife species but not likely to affect the species' sustainability in the RAA.
		High	Measurable effect on wildlife species but that will likely affect the species' sustainability in the RAA.)
Geographic Extent	The geographic area within which an environmental effect occurs	Local	Effect confined to the LAA
		Regional	Effect extends beyond the LAA but within the RAA
		Territorial	Effect extends beyond the RAA but within Nunavut
		National	Effect extends beyond Nunavut but within Canada
Frequency	Number of times that an effect may occur over the life of the Project	Once	Effect occurs once
		Sporadically	Effect occurs occasionally but not consistently throughout the life of the Project
		Regularly	Effect occurs at regular intervals throughout the life of the Project
		Continuous	Effect occurs continuously throughout the Project
Duration	Length of time over which the effect is measurable	Short term	Less than one year
		Medium term	More than one year, but not beyond the end of Project decommissioning
		Long term	Beyond the life of the Project
Reversibility	Likelihood that a measurable parameter for a VEC will recover from an environmental effect to baseline conditions	Reversible	Will likely recover to baseline conditions after or before the end of Project decommissioning
		Irreversible	Unlikely to recover to baseline conditions after the end of Project decommissioning

16.1.3 Standards or Thresholds for Determining Significance

Habitat – There is no known existing standard or threshold for determining a significant loss of habitat for short-eared owl. Based on professional opinion, experience from other northern Project, knowledge of short-eared owl ecology in arctic Canada, the relatively low number of occurrences of the species in the region, Project effects on habitat availability are considered significant if greater than 10% of habitat units in the RAA are affected

Health – There are no generic guidelines for Nunavut or Canada that are applicable to assess the effect of changes in biota based on their exposure to COPC. For this assessment, the estimated exposure to COPC by wildlife and birds is compared to values that are set to be protective of health and if the exposure is lower than this value then no adverse effects are expected. The estimated dose received by the biota from exposure to radioactivity, considering both baseline and Project emissions, is compared to a level that is protective of mammals and birds.

16.2 EFFECTS ASSESSMENT FOR SPECIES AT RISK

16.2.1 Assessment of Change in Habitat Availability – Short-eared Owl

The Kiggavik Project will result in a loss of short-eared owl habitat. Habitat availability can be affected by human developments through two pathways:

1. direct habitat loss from construction of the Project
2. indirect habitat loss from human activity associated with the Project that causes a functional loss of habitat

16.2.1.1 Analytical Methods for Change in Habitat Availability

Habitat availability for short-eared owl was assessed using the baseline ELC units were classified as High, Medium, Low or Nil based on the vegetative characteristics of the ELC units and the species' life requisites during the growing (breeding) season. Ratings were based on knowledge of short-eared owl habitat gained during a scientific literature review and field biologist observations.

To assess the overall loss of short-eared owl habitat availability within the RAA a habitat unit index was developed. The index is based on assigning a ranked value to each habitat class (e.g., high=3, moderate=2, low=1, nil=0), and summing the available habitat, measured in hectares, weighted by the value of each class. The difference in the weighted sum of available habitat for the baseline conditions, and the predicted direct and indirect loss of habitat indicate the expected loss of short-eared owl habitat.

The Project's footprint was quantified as a complete loss of habitat (i.e., rating "nil") and reduced habitat effectiveness within a ZOI for habitats proximate to mine facilities. Direct habitat loss is assessed by identifying ELC units that will become unavailable due to construction of the Project footprint. All ELC units within the Project footprint become "nil" quality once the Project is constructed. The winter road options will remove habitat in winter, but the habitat will be available again each summer when the road is decommissioned. Habitat effectiveness is addressed quantitatively by reducing habitat units by one or two categories, depending on their proximity to mine infrastructure within the ZOI. Details are provided below.

16.2.1.2 Baseline Conditions for Change in Habitat Availability

Short-eared owls were observed during the baseline surveys consisting of 11 different sitings (Tier 3, Appendix 6C). One nesting pair was suspected, though a nest site was not confirmed.

Short-eared owl populations can fluctuate yearly due to variation in cyclic small mammal populations, such as voles and lemmings, making local occurrence unpredictable (Clark 1975; Dechant et al. 2001). Short-eared owl nest site selection is typically associated with cyclic prey populations (Holt and Leasure 1993; Poulin et al. 2001). In Nunavut, higher concentrations of short-eared owl occur during years of lemming outbreaks (COSEWIC 2008).

Short-eared owls prefer open habitats such as arctic tundra (Johnsgard 1998), grasslands (Clark 1975), peat bogs (Mikkola 1983), fresh and saltwater marshes (Holt and Leasure, 1993), old pasture/croplands (Houston 1997), and shrub-steppe (Lehman et al. 1998). In the arctic, preferred nesting sites include tundra containing small willows (e.g., in Churchill region; Jehl 2004); generally in areas larger than 100 ha (Dechant et al. 2001). Nests are thought to be initiated in early June in northern ecosystems (Jehl 2004). ELC units that contain grasses, shrubs and willows are used by short-eared owls as nesting and feeding habitat (Clark 1975; Jehl 2004). ELC units that contain willow components are Graminoid/Shrub Tundra, Shrub Tundra and Shrub/Heath Tundra. Based on this information, ELC units were rated as high, medium, low or nil in the RAA (Table 16.2-1).

Table 16.2-1 Summary of Relative Value of Ecological Land Classification Units to Short-eared Owls

ELC Unit	Growing Season Ranking	Reasoning
Water	nil	Short-eared owls do not nest or are known to use open water habitats
Sand	L	Vegetation generally absent to sparse for supporting nesting short-eared owl; limited foraging opportunities
Gravel	L	Vegetation generally absent to sparse for supporting nesting short-eared owl; limited foraging opportunities
Rock Association	L	Pockets of vegetation are sparsely distributed and of variable suitability for supporting and concealing a nest. Rock Associations are good prey species habitat (lemmings and voles) for short-eared owls.

Table 16.2-1 Summary of Relative Value of Ecological Land Classification Units to Short-eared Owls (cont'd)

ELC Unit	Growing Season Ranking	Reasoning
Wet Graminoid	M	Small hummocks and rises within this habitat type provide moderate quality nesting habitat for short-eared owl. Habitat also of moderate to high quality for prey species (lemmings and voles).
Graminoid Tundra	H	High quality nesting and foraging habitat for short-eared owl; prey species abundant in this habitat
Graminoid/ Shrub Tundra	H	High quality nesting and foraging habitat for short-eared owl; prey species abundant in this habitat
Shrub Tundra	H	High quality nesting and foraging habitat for short-eared owl; prey species abundant in this habitat
Shrub/Heath Tundra	H	High quality nesting and foraging habitat for short-eared owl; prey species abundant in this habitat
Heath Tundra	M	Moderate quality nesting and foraging habitat for short-eared owls; prey species abundant in this habitat
Heath Upland	M	Vegetative cover generally well-represented, but vertical structure suitable for nesting short-eared occurs in small pockets. Habitat contains prey for short-eared owl
Lichen Tundra	L	Vegetation inadequate as short-eared owl nesting habitat, and moderately suitable for supporting prey (voles)
Heath Upland/Rock Complex	L	Vegetation inadequate as short-eared owl nesting habitat, and moderately suitable for supporting prey (voles)
NOTE: H = High; M = Moderate; L = Low		

16.2.1.3 Effect Mechanisms and Linkages for Change in Habitat Availability

The primary threat to short-eared owls across their North American range is loss of prairie habitat in southern Canada and USA (COSEWIC 2008). The Project has the potential to affect short-eared owl habitat by removing probable or actual nesting and foraging sites. Areas such as large grasslands and wetlands that support high densities of prey species (e.g., lemmings) are key to reducing Project effects on short-eared owl (Dechant et al. 2001).

Short-eared owls are known to avoid areas of disturbance. The use of habitat may be affected by proximity to disturbance, such as buildings and roads. For example, Combs-Bettie (1993) found that the average distance of nests to buildings was approximately 789 m, with a minimum distance of 250 m. There is no other known literature on the influence of development on short-eared owl nesting and there was no IQ collected on the potential influence of development on short-eared owl nesting. For the purposes of this assessment, all habitats within 250 m of Project facilities (mine, roads, buildings, ports) were reduced to low quality. All habitats from 250 m to 1 km from the edge of the Project footprint are reduced by one habitat category to a minimum of low (Table 16.2-2). Habitat beyond 1 km remains as baseline conditions.

Table 16.2-2 Summary of the Zone of Influence used to calculate reduced habitat effectiveness for Short-eared Owl

Project infrastructure	ZOI (Radius from Edge of Footprint)	Habitat Reduction	Justification
Mine	0 – 0.25 km	2 class reduction to a minimum of Low	Combs-Bettie (1993)
	0.25 – 1 km	1 class reduction to a minimum of Low	Combs-Bettie (1993)
North All-Season Road	0 – 0.25 km	2 class reduction to a minimum of Low	Combs-Bettie (1993)
	0.25 – 1 km	1 class reduction to a minimum of Low	Combs-Bettie (1993)
North Winter Road	n/a	No change	Owls are not present in the RAA during winter road operation
South Winter Road	n/a	No change	Owls are not present in the RAA during winter road operation

16.2.1.4 Mitigation Measures and Project Design for Change in Habitat Availability

Mitigation measures that will be implemented to minimize effects on habitat availability for short-eared owls include the following:

- If possible, construction activities involving site clearing will be scheduled to occur outside of the breeding and nesting period for migratory birds (i.e., May to July).
- Site clearing and any other disturbances to the landscape will be kept within the confines of the pre-surveyed Project Footprint boundaries.
- Prior to clearing activities during the breeding bird season, all areas within the construction area will be searched for nests. Active nests will be identified and for short-eared owl, an 800 m radius no-disturbance buffer will be applied until nesting is complete and chicks have fledged.
- All on-site observations of short-eared owl will be investigated to determine presence of nests sites. Active nests will be marked as described above with an 800 m radius no-disturbance buffer.
- Reclamation will include the establishment of shrub cover which will provide small mammal (prey) habitat and potential nesting habitat

These mitigation measures are readily implemented by on-site environmental staff.

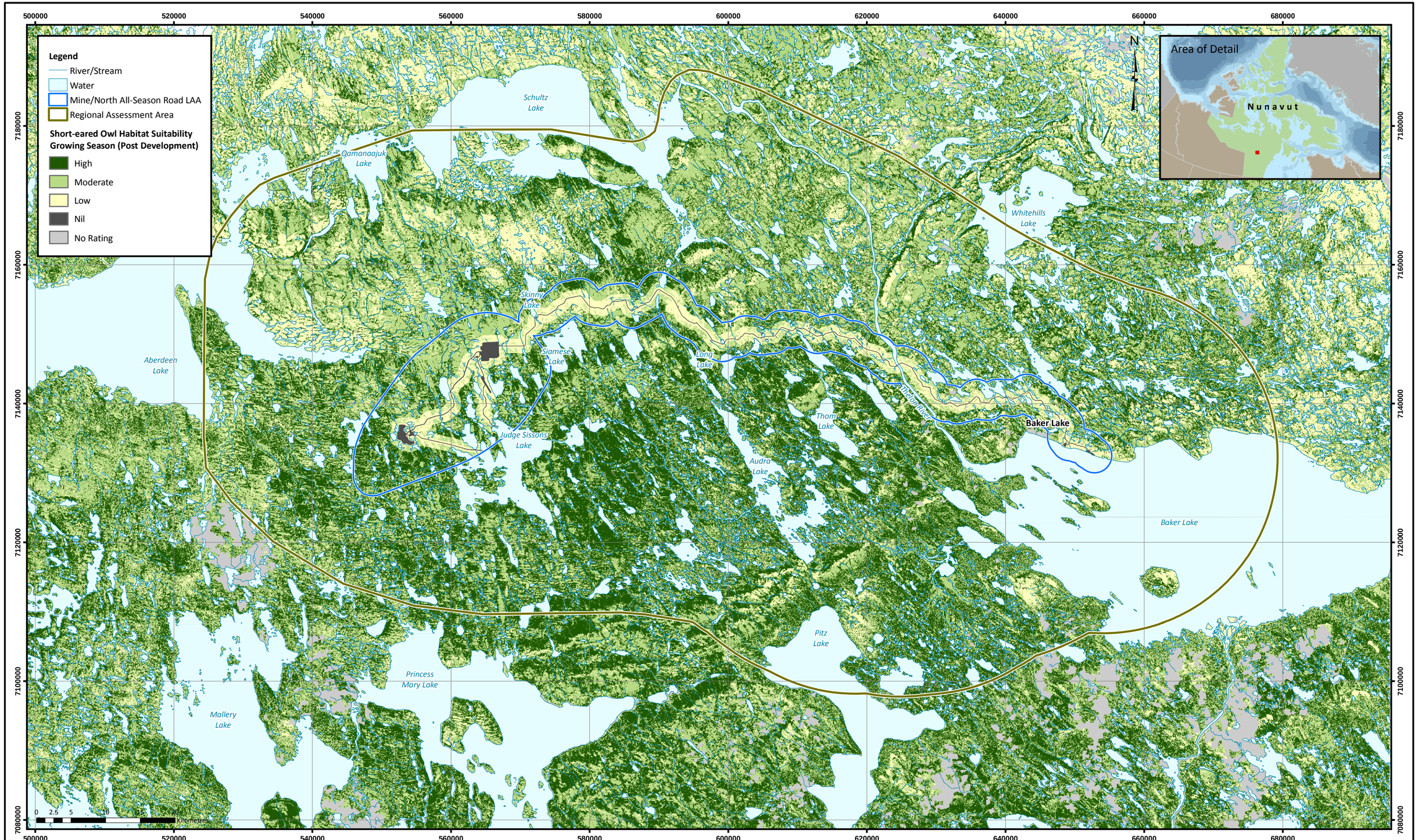
16.2.1.5 Residual Effects for Change in Habitat Availability

16.2.1.5.1 Mine and North All-Season Road

Of the three Project options, the North All-Season Road will have the greatest effect on short-eared owl habitat because of the larger footprint and sensory disturbance from road traffic. The road's footprint results in long-term habitat loss. The operation of the road during the breeding season could result in sensory disturbance (e.g., avoidance of areas with traffic noise) or habitat effects (e.g., dust effects on small mammal forage, reducing small mammal abundance in areas of high dust settlement). Within the LAA, the Project will result in a loss of 32.4% of available high quality habitat, which equates to an overall loss of 16.8% of available habitat. Within the RAA, the Project will result in a loss of 3.6% of available high quality habitat, which equates to an overall loss of 1.9% of available habitat. The baseline versus operation scenario of habitat in the LAA and RAA is presented in Table 16.2-3 and Figure16.2-1.

Table 16.2-3 Mine and North All-Season Road Baseline and Operations Habitat Quality for Short-eared Owls

Area	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	
	Class	Value	ha	ha	ha	ha	%
LAA	High	3	33,947	-655	-10,348	22,943	-32.4
	Moderate	2	43,048	-940	-7,951	34,156	-20.7
	Low	1	6,031	-84	18,300	24,246	302.0
	Nil	0	13,747	-23	0	15,428	12.2
	No Rating		163	0	0	163	0.0
	Total		**96,936**	**-1,704**	**0**	**96,936**	**-16.8**
RAA	High	3	303,661	-655	-10,353	292,653	-3.6
	Moderate	2	344,075	-940	-7,960	335,175	-2.6
	Low	1	81,308	-84	18,313	99,536	22.4
	Nil	0	251,110	-23	0	252,790	0.7
	No Rating		2,583	0	0	2,583	0.0
	Total		**982,738**	**-1,704**	**0**	**982,738**	**-1.9**



Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 12/05/2011 Scale: 1:500,000
File: 16.2-1_Habitat_Suitability_Growing_PD_Short-eared_Owl.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.*

FIGURE 16.2-1
POST-DEVELOPMENT SHORT-EARED OWL HABITAT SUITABILITY - GROWING SEASON
MINE AND NORTH ALL-SEASON ROAD

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project

AREVA

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16.2.1.5.2 Mine and Winter Roads

Residual effects are limited to operations at the Mine and within the Mine portion of the LAA. Within the LAA, the Project will result in a loss of 22.5% of available high quality habitat, which equates to an overall loss of 13.1% of available habitat. Within the RAA the Project results in a loss of 1.3% of available high quality habitat, which equates to an overall loss of 0.7% of available habitat. Short-eared owls migrate south for the winter; therefore, the potential for an interaction with the Project and the winter road during the winter is not anticipated. The baseline versus operation scenario of habitat in the LAA and RAA is presented in Table 16.2-4.

Table 16.2-4 Mine and South Winter Road Baseline and Operations Habitat Quality for Short-eared Owls

Area	Habitat Rating		Baseline ELC	Direct Loss	Indirect Loss	Project Effect	
	Class	Value	ha	ha	ha	ha	%
LAA	High	3	16,973	-548	-3,278	13,147	-22.5
	Moderate	2	20,580	-792	-2,468	17,320	-15.8
	Low	1	1,377	-16	5,746	7,107	416.2
	Nil	0	6,080	-22	0	7,435	22.3
	No Rating		0	0	0	0	NA
	Total		**45,009**	**-1,378**	**0**	**45,009**	**-13.1**
RAA	High	3	303,661	-548	-3,282	299,831	-1.3
	Moderate	2	344,075	-792	-2,476	340,808	-0.9
	Low	1	81,308	-16	5,758	87,050	7.1
	Nil	0	251,110	-22	0	252,466	0.5
	No Rating		2,583	0	0	2,583	0.0
	Total		**982,738**	**-1,378**	**0**	**982,738**	**-0.7**

16.2.1.6 Determination of Significance for Change in Habitat Availability

The Project will result in the long-term loss of some nesting and foraging habitat for Short-eared owls. The change in habitat will be measureable, but will be limited to the Project footprint (complete loss) and within the LAA (Table 16.2-5). Reduced habitat effectiveness is reversible once operations cease. Overall, Project effects on Short-eared owl nesting and foraging habitat is predicted to be not significant. The confidence in this prediction is rated as moderate as short-eared owls are known to respond adversely to habitat loss and alteration, and the Project will result in a loss of foraging and nesting habitat. While the exact extent of the ZOI is uncertain due to indirect habitat loss caused by the Project, the ZOI is a conservative estimate.

16.2.1.7 Summary of Project Residual Environmental Effects for Habitat Availability of Short-eared Owl

Table 16.2-5 summarizes the Project residual effects for habitat availability for short-eared owl.

16.2.1.8 Compliance and Environmental Monitoring for Change in Habitat Availability

The extent of the Project footprint will be assessed on an annual basis to confirm habitat loss predictions.

16.2.2 Assessment of Change in Health — Species at Risk

Emissions from the Project have the potential to expose species at risk (i.e., short-eared owl, grizzly bear, and wolverine) to COPC. The potential for emissions to cause adverse effects to species at risk was evaluated.

In the Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A), the peregrine falcon was selected to represent all types of birds of prey (including short-eared owl). The short-eared owl's diet comprises a larger fraction of small mammals compared to the peregrine falcon but this diet variation is accounted for within the uncertainty included in the Ecological Risk Assessment. There are no residual effects with respect to peregrine falcon health due to emissions created by the Project; thus, it is anticipated that there are no residual effects on the health of short-eared owls either. Therefore, short-eared owl is not specifically included in this assessment.

16.2.2.1 Analytical Methods for Change in Health

Emissions from the Project can the influence COPC concentrations in environment components (e.g., water, soil, fish), which in turn could potentially influence COPC concentrations in grizzly bears and wolverines that consume these environmental components. The COPC included in this assessment were uranium and the uranium-238 decay series (thorium-230, lead-210, radium-226, and polonium-210), arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, and zinc.

Table 16.2-5 Summary of Project Residual Environmental Effects for Short-eared Owl — Habitat Availability

Project Phase	Mitigation / Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Change in Short-eared owl Habitat Availability –Mine + North All-Season Road												
Construction	Pre-clearing nest searches; no-disturbance buffers; reclamation	N	M	L	LT	S	I	U	N	N/A	M	No disturbance buffers around SAR breeding sites through to completion of breeding.
Operation		N	M	L	MT	R	R	U	N	N/A	M	
Final Closure		N	M	L	MT	O	I	U	N	N/A	M	
Change in Short-eared owl Habitat Availability – Mine + Winter Road Options												
Construction	Pre-clearing nest searches; no-disturbance buffers; reclamation	N	M	L	LT	S	I	U	N	N/A	M	No disturbance buffers around SAR breeding sites through to completion of breeding.
Operation		N	M	L	MT	R	R	U	N	N/A	M	
Final Closure		N	M	L	MT	O	I	U	N	N/A	M	

Table 16.2-5 Summary of Project Residual Environmental Effects for Short-eared Owl — Habitat Availability (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible: No anticipated effect on wildlife species.

L Low: Observable effect on wildlife species but not likely to affect the species' sustainability in the Project area.

M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the region.

H High: Measurable effect on wildlife species but that will likely affect the species' sustainability in the region.

Geographic Extent:

S Site-specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities.

Grizzly bears forage on mammals and migrating salmon, but also rely heavily on vegetation (specifically berries) for food. Wolverine is an opportunistic carnivore and will consume carrion from large mammal kills by other carnivores as well as hunting for birds and small and medium-sized mammals. To estimate animal exposure, the predicted COPC concentrations in all environmental components that could potentially be consumed were included in the analysis. Detailed air quality modelling (Tier 2, Volume 4) and water quality modelling (Tier 2, Volume 5) are used as inputs to the environmental pathways assessment. The concentrations in environmental components are predicted by using transfer factors that relate the concentration in different components (e.g., soil-to-plant). Transfer factors are based on site-specific information where possible, augmented by literature data. COPC intake in birds and small mammals is calculated by multiplying a separate transfer factor to obtain COPC concentration in these animals. These concentrations are used for representing the prey. The pathways assessment is discussed in further detail in the Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A).

COPC intake in grizzly bears and wolverines is estimated based on predicted COPC concentrations in prey, as well as using assumptions regarding how much prey is consumed. The amount of time both the prey items and the carnivores spend within the exposure area is also an important factor. Grizzly bear and wolverine were assumed to spend half of their time in the LAA. In addition, the wolverine was assumed to reside entirely within the RAA. The estimated intakes were compared to benchmarks considered safe for mammals. For estimating radionuclide dose, the concentration within the animal of each radionuclide is estimated from the calculated intake through the use of a transfer factor. Dose coefficients are used to estimate the dose from each radionuclide based on the concentration. Radiation effects on biota depend not only on the absorbed dose, but also on the relative biological effectiveness (RBE) of the particular radiation (i.e., alpha, beta or gamma radiation). Recent recommendations have focused on an RBE of 10 for alpha radiation; however, to illustrate the effects of uncertainty in RBE a range was examined. The total dose, which is based on the baseline plus Project emissions for the sum of the uranium-series radionuclides, is compared to a benchmark that is protective of mammals (1 mGy/d).

The bounding scenario carried through the ecological assessment was based on separate discharges from the Kiggavik and Sissons WTPs, an extended operating period (25 years) followed by a 22-year period of consolidation where water treatment would be required. The assessment accounted for the uncertainty and variability in the emissions and the behaviour in the environment. The details are provided in the Ecological and Human Health Risk Assessment report (Appendix 8A).

16.2.2.2 Baseline Conditions for Change in Health

Under baseline conditions, grizzly bear and wolverine are exposed to naturally occurring COPC concentrations in the environment. Concentrations of COPC in food items (e.g., fish, berries, small mammals such as voles and lemmings) were measured and this baseline information was used to make sure the current conditions were reflected in the pathways assessment.

16.2.2.3 Effect Mechanisms and Linkages for Change in Health

Changes in the health of species at risk can occur if they are exposed to COPC at levels that are associated with an effect. As it is important to maintain these populations, the potential for a COPC to affect the growth and reproduction of the biota is examined. The assessment of changes in health of the biota depends on the estimated changes in concentrations of environmental components such as vegetation and soil, which are derived from the atmospheric and aquatic environment assessments.

The Project-environment interactions and effects described in the Atmospheric Environment (Tier 2, Volume 4) and the Aquatic Environment (Tier 2, Volume 5) reports form the basis for the effects mechanisms and linkages. The Project air quality effects relate to emissions of dust containing COPC from open pit and underground mining and supporting activities, milling and vehicle traffic on unpaved roads. The Project water quality effects relate to emissions of COPC from WTPs at the Kiggavik and Sissons sites. Complete details about the COPC sources and all assumptions used in the assessments were provided in the atmospheric and aquatic environment assessments.

16.2.2.4 Mitigation Measures and Project Design for Change in Health

Design aspects, operational measures and other mitigation measures have been incorporated into the current Project design, which will minimize Project-associated emissions and/or the potential effect of Project-related emissions.

The Atmospheric Environment report (Tier 2, Volume 4) provides a detailed list of the mitigation measures applied to reduce the changes to ambient air quality. Mitigation measures that have been incorporated to reduce emissions of dust containing COPC are:

- Minimizing or reducing vehicle speed on unpaved mine site roads (including pit ramps) and the Kiggavik-Sissons access road and enforce speed limits, where possible
- Applying water or another approved dust suppressant to the surfaces of unpaved mine site roads (including pit ramps) and the Kiggavik-Sissons access road, when possible
- Maintaining all unpaved road surfaces via grading or other maintenance practices to minimize the amount of silt (i.e., fine particles) present in the roadbed material
- Installing appropriate air pollution controls on the exhaust stacks of the mill complex and acid plant (e.g., wet scrubbers, dust collectors) and
- Releasing tailings to the TMFs as a slurry below a water surface to avoid tailings dust emissions

The Kiggavik WTP and Sissons WTP have been designed so that the effluent will meet all appropriate regulations such as the MMER as well as site-specific discharge limits. Environmental considerations were paramount in the selection of the appropriate technology for the WTP. Further detail on the design of the WTP can be found in the Project Description report (Tier 2, Volume 2).

16.2.2.5 Residual Effects for Change in Health

In this study, adverse effects from exposure to COPC were characterized by a simple screening index. This index was calculated by dividing the predicted exposure by the toxicity reference value for each ecological receptor as follows:

$$Screening\ Index = \frac{Exposure}{Toxicity\ Reference\ Value}$$

For the wildlife species, the US EPA risk-based ecological soil screening levels (Eco-SSLs) (US EPA 2010) were used as the primary data source for the derivation of toxicity reference values used to determine the potential for an effect. For this assessment, the lowest observable adverse effect levels (LOAELs) based on growth and reproduction were selected, as these endpoints are the most relevant for the maintenance and persistence of wildlife populations.

For COPC without Eco-SSL data (in this case uranium), literature studies were reviewed and values from long-term (chronic) exposure studies were selected. The Eco-SSL database provides information for a number of different species that could be used as a surrogate for other species with similar diets. For example, for arsenic the value for a dog is used as the surrogate for the bear and wolverine. If none of the test species were similar to the ecological receptors selected in this assessment, then the lowest value was selected as the conservative default benchmark for the ecological receptor. The Ecological and Human Health Risk Assessment report (Tier 3, Appendix 8A) provides the final selected values along with additional detail on the derivation and rationale for the value.

Screening index values are not estimates of the probability of ecological effect. Rather, the index values are correlated with the potential of an effect, e.g., higher index values imply a greater potential of an effect. The estimated exposure of grizzly bear and wolverine includes both the natural baseline levels as well as the effect of the Project emissions. Therefore, a screening index value less than 1.0 indicates that the estimated total exposure is less than the threshold that is associated with a potential adverse effect. The screening index values for grizzly bear and wolverine are shown in Table 16.2-6.

Table 16.2-6 Screening Index Values for Species at Risk

COPC	Screening Index (SI)			
	Grizzly bear		Wolverine	
	Baseline	Present in Local Assessment Area	Baseline	Present in Local Assessment Area
Arsenic	0.002	0.002	0.001	0.001
Cadmium	0.009	0.009	0.004	0.006
Cobalt	<0.001	<0.001	<0.001	<0.001
Copper	0.016	0.016	0.031	0.032
Lead	<0.001	<0.001	<0.001	<0.001
Molybdenum	0.007	0.007	0.007	0.007
Nickel	<0.001	<0.001	<0.001	<0.001
Selenium	0.038	0.040	0.031	0.031
Uranium	<0.001	<0.001	<0.001	<0.001
Zinc	0.106	0.106	0.168	0.168
Radioactivity	<0.01	<0.01	<0.01	<0.01

NOTES:
SI values for non-radiological COPC are based on the maximum mean exposure compared to a LOAEL
SI values of radiological effects include the contribution from U-238, Th-230, Ra-226, Pb-210 and Po-210, using an RBE of 40 and compared to a benchmark of 1 mGy/d
Details of calculation as well as additional results provided in Tier 3, Appendix 8A

Emissions from the Project are not anticipated to result in a discernible change in exposure to COPC concentrations for these species. In addition, the results show that grizzly bear and wolverine exposure to COPC concentrations will not exceed exposure levels associated with adverse effects.

16.2.2.6 Determination of Significance for Change in Health

Grizzly bear and wolverine health are not expected to change from baseline values of exposure, and the exposure will remain below levels associated with adverse effects. Therefore, no residual effects are expected on the health of these species.

16.2.2.7 Compliance and Environmental Monitoring for Change in Health

No specific monitoring requirements are recommended based on the assessment for change in health of species at risk. The monitoring of other environmental components (e.g., water, fish, berries) will provide information for confirming the results of the assessment.

16.3 CUMULATIVE EFFECTS ANALYSIS FOR SPECIES AT RISK

16.3.1 Screening for Cumulative Environmental Effects

Project effects on habitat availability have the potential to act cumulatively with effects from other projects. Residual effects on reduced habitat availability are expected as the Project Footprint will cause a habitat loss that will extend beyond the life of the Project. Mitigation measures to reduce Project effects on habitat availability will likely only partially mitigate these effects. Project effects will likely be similar to effects from current and future development activities that could interact with the Project, and will overlap in time and space. The cumulative effect of a change in habitat availability for short-eared owls was assessed.

There are no Project environmental effects predicted for other Species at Risk and, therefore, they are not considered in this cumulative effects assessment.

16.3.2 Assessment of the Cumulative Effects: Change in Habitat Availability

COSEWIC (2008) and Austen et al. (1994) identified the loss of prairie breeding habitat as a threat to short-eared owls. Short-eared owls are irruptive breeders and nesting success appears to be in part a response to local small mammal populations. Additionally, short-eared owls are near the northern extent of their range in the Project Area. It is unlikely that habitat for nesting is a limiting feature in mainland Nunavut. Therefore, the Project is not expected to result in a measurable or reasonably expected cumulative effect on short-eared owl habitat in arctic Canada.

16.3.2.1 Effect Mechanisms and Linkages for Cumulative Change in Habitat Availability

The cumulative direct loss of short-eared owl habitat will reduce the amount of available habitat regionally, but this effect will not result in measurable or detectable changes in the region. Indirect loss of short-eared owl habitat from human disturbance that results in avoidance is the largest source of habitat loss. While human disturbance causes a loss of habitat, the effect is temporary as it occurs only while there is human activity. For the Kiggavik Project to cause a significant additional functional loss of habitat in the region, other human disturbances need to overlap temporally.

Current human disturbance within the Kivalliq region that could reduce the availability of nesting habitat for short-eared owl include:

- Meadowbank Mine — The footprint of the mine and mine access road has reduced the availability of short-eared owl habitat during the growing season. Activity at the mine site and transportation to the mine from Baker Lake has indirectly reduced the availability of short-eared owl habitat in the area. The Meadowbank Mine is expected to operate until 2019.
- Mineral Exploration Operations — There are numerous mineral deposits being explored in the region. Each of these operations has some amount of human activity (e.g., drilling, surveying). Exploration activities mostly take place during the summer and the footprint of the camps, drill pads and other disturbances is relatively small.
- Local Communities — The footprint of Arviat, Whale Cove, Rankin Inlet, Chesterfield Inlet and Baker Lake reduces the availability of habitat of short-eared owl habitat. Sensory disturbance from vehicles, generators, aircraft traffic and other human activities in these communities indirectly reduce the availability of short-eared owl breeding habitat.

The Kiggavik Project will add to the overall loss of short-eared owl habitat. While there are a number of mineral exploration operations in the region, few exploration projects may turn into active mines. Therefore, it is unlikely that the Kiggavik Project will overlap temporally with operating mines or other industrial developments in the region.

16.3.2.2 Mitigation Measures for Cumulative Change in Habitat Availability

Mitigation measures for cumulative changes in habitat availability are the same as those presented for the Project Case. No further mitigations are necessary to mitigate cumulative effects of the Project on short-eared owls.

16.3.2.3 Residual Cumulative Change in Habitat Availability

The magnitude of effects of the Project on short-eared owl habitat is expected to be negligible. Few projects are expected to overlap temporally with the Kiggavik within the Kivalliq region.

16.3.2.4 Determination of Significance for Cumulative Change in Habitat Availability

Currently, there are few human activities in the region that affect short-eared owls. The Meadowbank mine and regional communities are currently the greatest sources of habitat loss for short-eared owls. The addition of the Kiggavik Project to these disturbances is not expected to measurably reduce the amount of available short-eared owl habitat. Mineral exploration is

currently not causing significant loss of habitat. Although there is the potential for future mine development in the region, given the history of such development the likelihood of multiple future mines existing at the same time as the Kiggavik Project is low. The cumulative change to habitat availability for short-eared owls is, therefore, assessed as not significant.

The predicted magnitude of Project effects species at risk is rated as low because there are few land uses planned in the region that will overlap temporally and spatially with the Kiggavik Project. Confidence in this prediction is high because effects of the Project on the short-eared owl will be limited to the LAA and will not cause changes to the population at the regional scale.

16.3.2.5 Compliance and Environmental Monitoring for Cumulative Change in Habitat Availability

Compliance and environmental monitoring for cumulative changes in habitat availability are the same as those presented for the Project Case.

16.3.3 Summary of Residual Cumulative Environmental Effects on Species at Risk

Table 16.3-1 summarizes the cumulative environmental effects of the Project on species at risk.

16.4 SUMMARY OF RESIDUAL EFFECTS ON SPECIES AT RISK

16.4.1 Project Effects

The Kiggavik Project will result in the loss of existing and potential short-eared owl habitat, but this effect is assessed as not significant. In particular, the Project footprint may reduce the quality of foraging and nesting habitat for short-eared owls. Effects on habitat from the Kiggavik Project could act cumulatively with similar effects from other human activity and industrial projects in the area.

16.4.2 Cumulative Effects

The cumulative change to habitat availability for short-eared owls is assessed as not significant. Few projects are expected to overlap temporally with the Project within the region.

Table 16.3-1 Summary of Residual Cumulative Environmental Effects on Species at Risk — Short-eared Owl Habitat Availability

Cumulative Environmental Effect	Case	Other Projects, Activities and Actions	Mitigation and Compensation Measures	Residual Cumulative Environmental Effects Characteristics							Significance	Prediction Confidence	Likelihood	Proposed Follow-up and Monitoring Programs
				Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Context				
Changes in Habitat Availability	Cumulative Effect with Project (Future Case)	Meadowbank Mine, various exploration operations, and various regional communities	Dust management; Minimize Project footprint; Progressive reclamation	N	N	L	LT	C	R	D	N	H	N/A	None
	Project Contribution to Cumulative Effect	NA	NA	N	N	L	LT	C	R	D	N	H	N/A	NA

Table 16.3-1 Summary of Residual Cumulative Environmental Effects on Species at Risk — Short-eared Owl Habitat Availability (cont'd)

KEY

Direction:

P Positive

N Negative

Magnitude:

N Negligible: No anticipated effect on wildlife species.

L Low: Observable effect on wildlife species but not likely to affect the species' sustainability in the Project area.

M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the region.

H High: Measurable effect on wildlife species but that will likely affect the species' sustainability in the species range.

Geographic Extent:

S Site-specific

L Local: Effect confined to the LAA

R Regional - Effect extends beyond the LAA but within the RAA

T Territorial: Effect extends beyond the RAA but within Nunavut

N National: Effect extends beyond Nunavut but within Canada

Duration:

ST Short term: Less than one year

MT Medium term: More than one year, but not beyond the end of Project decommissioning

LT Long term: Beyond the life of the Project

Frequency:

O Once: Effect occurs once

S Sporadically: Effect occurs occasionally but not consistently throughout the life of the Project

R Regularly: Effect occurs at regular intervals throughout the life of the Project

C Continuous: Effect occurs continuously throughout the Project

Reversibility:

R Reversible: Will likely recover to baseline conditions after or before the end of Project decommissioning

I Irreversible: Unlikely to recover to baseline conditions after the end of Project decommissioning

Environmental Context:

U Undisturbed: Area relatively or not adversely affected by human activity

D Developed: Area has been substantially previously disturbed by human development or human development is still present

N/A Not Applicable

Significance:

S Significant

N Not significant

Prediction Confidence:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation

L Low level of confidence

M Moderate level of confidence

H High level of confidence

Likelihood of Significant Effects:

Based on professional judgment

L Low probability of occurrence

M Medium probability of occurrence

H High probability of occurrence

Other Projects, Activities and Actions:

Human disturbance associated with Meadowbank Mine, various exploration operations, and various regional communities.

16.4.3 Effects of Climate Change on Species at Risk and Habitat

Climate change occurs continuously at a global scale and will likely have long-term effects on wildlife and habitats. Climate change could exacerbate effects on Species at Risk, especially if they are already subject to current environmental pressures. Effects of climate change on Project and cumulative effects on Species at Risk are expected to occur independently and are not expected to act in combination with any other Project-specific effects.

16.5 TRANSBOUNDARY EFFECTS

There are no transboundary effects of the limited habitat loss for short-eared owls. Habitat loss is limited to the footprint of the Project and the operations ZOI (i.e., up to 800 m from Project facilities and activities).

16.6 SUMMARY OF MITIGATION MEASURES FOR SPECIES AT RISK

All sightings of Species at Risk will be communicated to the on-site environmental manager as a priority for possible environmental management actions. Where sightings may indicate potential nesting or denning, a site investigation of the reported observation will be conducted to determine if operations may interact negatively with the breeding site. Mitigation for species at risk breeding sites that may interact with the Project will be dealt with as indicated in the mitigation measures sections.

16.7 SUMMARY OF COMPLIANCE AND ENVIRONMENTAL MONITORING FOR SPECIES AT RISK

Occurrence of species at risk in the LAA is expected to be rare and infrequent. Short-eared owl monitoring during construction will include pre-disturbance active nest monitoring programs where an 800 m no-disturbance buffer will be placed around the nest until fledgling is complete. Monitoring during operation will include on-site observations of nesting by short-eared owl and an 800 m (if possible up to extent of on-going Project activities) will be used. Grizzly bear and wolverine sightings will be noted and investigations will be conducted should their sightings be associated with changes to the camp waste program. Problem wildlife will be reported to regional Conservation Officers, and camp waste management will be adjusted as necessary to eliminate attracting problem wildlife.

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18 SUMMARY OF PROJECT RESIDUAL EFFECTS ON THE TERRESTRIAL ENVIRONMENT

18.1 TERRAIN, SOILS AND VEGETATION

18.1.1 Terrain

18.1.1.1 Permafrost Conditions and Terrain Stability

Project residual effects on permafrost conditions and terrain stability will be confined within the Project footprint and are predicted to be not significant. The total disturbed area will encompass about 803 ha, which represents 2.2% of the mine LAA. This will be caused by vegetation clearing, organic soil and frozen overburden stripping (645 ha or 1.8% of the mine LAA) and burial (158 ha or 0.4% of the mine LAA). The residual effects are predicted to be low in magnitude, site specific, long term, continuous over the life of the Project, and reversible. The confidence in this prediction is rated as high. With the implementation of mitigation measures, the residual effects on changes to permafrost conditions and terrain stability are anticipated to be negligible.

18.1.1.2 Landforms

Project residual effects on common depositional landforms are predicted to be not significant. The estimated surface areas covered by alluvial, glaciomarine, bedrock and morainal (glacial till) landforms that will be disturbed by the Project encompass 0.06%, 0.001%, 0.19% and 1.99% of the total area of mine LAA, respectively, which represent about 2.2% of the mine LAA in total. The residual effects of changes in landforms are predicted to be low in magnitude, site specific, long term, will likely occur once, and irreversible. The confidence in this prediction is rated as high. With the implementation of mitigation measures during design and construction phases of the Project, the residual effects on changes to landforms are anticipated to be negligible.

18.1.2 Soils

18.1.2.1 Soil Quality

The effect of the Project on soil quality is assessed as not significant. Changes in COPC concentrations were predicted to be below the CCME (2009) soil quality guidelines. About 81 ha of soil located outside of the Project footprint have the potential to be exposed to PAI greater than the threshold value, which represents approximately 0.2 % of the mine LAA. The residual

effects caused by soil admixing, compaction and erosion are anticipated to be negligible with the implementation of effective mitigation measures. The confidence in this prediction is rated as high.

18.1.2.2 Soil Quantity

The effect of the Project on soil quantity is assessed as not significant. Depending on the Project development option selected, changes in soil quantity are predicted to occur within an area of between 953 ha and 1,212 ha, both of which represent less than 1% of the combined LAAs. Of this total, about 645 ha will be disturbed by topsoil stripping and an additional 208 ha to 567 ha will be disturbed from soil burial. The confidence in this prediction is rated as high.

18.1.3 Vegetation

Project residual effects on vegetation is discussed in relation to vegetation abundance and community diversity, and vegetation quality.

18.1.3.1 Vegetation Abundance and Community Diversity

Project residual effects on vegetation abundance and community diversity are predicted to be not significant. Depending on the Project development option selected, the total disturbed area will range between 1,449 ha and 1,708 ha of upland area, which represents between 1.1% and 1.4% of the combined LAAs, respectively. The confidence in this prediction is rated as high.

18.1.3.2 Vegetation Quality

Project residual effects on vegetation quality are predicted to be not significant. Changes in these analyte concentrations are not anticipated to exceed upper thresholds; therefore, no adverse effects on vegetation quality are expected to occur. PAI levels greater than the critical load threshold value are predicted to occur over 81 ha adjacent to the Kiggavik mine site, affecting approximately 0.2% of the mine LAA. No residual effects from NO_2 and SO_2 concentrations on vegetation are anticipated to occur, as generated emissions are predicted to be below threshold values. Effects of dust deposition on vegetation are predicted to be located immediately adjacent to the Kiggavik and Sissons mine sites, spanning a combined area of about 36 ha. Dust deposition along the proposed access roads is anticipated to be negligible, with a predicted annual deposition of 0.1 g/m^2. The confidence in this prediction is rated as moderate.

18.2 TERRESTRIAL WILDLIFE

Project residual effects on wildlife and habitat is discussed in relation to caribou and muskox, peregrine falcon (representing raptors), lapland longspur and long-tailed duck (representing migratory birds) and short-eared owl, grizzly bear and wolverine (representing Species at Risk).

18.2.1 Caribou and Muskox

18.2.1.1 Mortality Risk

The Project will result in a not significant effect on terrestrial wildlife mortality risk. AREVA is able to mitigate potential sources of direct and indirect mortality. Managing public access to and vehicle speed along the roadways are the primary mitigations needed to reduce the potential for Project-related mortality. The change in ungulate mortality will be negligible because no caribou or muskox mortality is expected along the roadways. The confidence in this prediction is rated as moderate because the responsibility for mitigation is not entirely in control of AREVA. Participation is expected from wildlife management authorities and the local and regional wildlife organizations.

18.2.1.2 Habitat Availability

The Project will result in a not significant effect on terrestrial wildlife habitat availability. There will be a long-term loss of some ungulate habitat within the Project footprint and a reversible loss of habitat effectiveness within the Project ZOI. The change in available habitat will be measurable, but will be not significant at the scale of the ranges of wildlife species indicators that could interact with the Project. The confidence in this prediction is rated as moderate.

18.2.1.3 Movement

The Project will result in a not significant effect on caribou movement. Few caribou are expected to interact with the Project during the migratory seasons and the Project is not within 10 km of any designated water crossing. The confidence in this prediction is rated as moderate.

18.2.1.4 Health

The Project will result in a not significant effect on caribou and muskox health from exposure to COPC. The confidence in this prediction is rated as high.

18.2.2 Raptors

18.2.2.1 Habitat Availability for Peregrine Falcon

The Project will result in a not significant effect on raptor habitat availability. There will be a long-term loss of some raptor habitat within the Project footprint and a reversible loss of habitat effectiveness within the Project ZOI. The change in available habitat will be measurable, but will only be detectable within the LAA. The confidence in this prediction is rated as moderate.

18.2.2.2 Productivity of Peregrine Falcon

The Project will result in a not significant effect on raptor nest productivity. Nest sites are only known to occur near the North All-Season road. Activity along the winter road will not interact with nesting raptors. The greatest potential effect to raptor nest productivity will occur during the construction phase of the Project because of intensive human activity along the all-season road, but few nests occur in proximity to the road. Consequently, the magnitude of the effect is rated as moderate during construction, low during operation, and negligible after mine operation ends. The confidence in this prediction is rated as moderate during construction (assuming the birds will respond to proposed mitigation), and high during operation and final closure.

18.2.2.3 Health of Peregrine Falcon

The Project will result in a not significant effect on raptor health from exposure to COPC. The confidence in this prediction is rated as high.

18.2.3 Migratory Birds

18.2.3.1 Habitat Availability for Lapland Longspur and Long-tailed Duck

The Project will result in a not significant effect on migratory bird habitat availability. There will be a long-term loss of some migratory bird habitat within the Project footprint and a reversible loss of habitat effectiveness within the Project ZOI. The change in available habitat will be measurable, but will only be detectable within the LAA. The confidence in this prediction is rated as moderate.

18.2.3.2 Health of Lapland Longspur and Long-tailed Duck

The Project will result in a not significant effect on migratory bird health from exposure to COPC. The confidence in this prediction is rated as high.

18.2.4 Species at Risk

18.2.4.1 Short-eared Owl

18.2.4.1.1 Habitat

The Project will result in the long-term loss of some nesting and foraging habitat for short-eared owls. The change in habitat will be measureable, but will be limited to the footprint (complete loss) and within the LAA. Reduced habitat effectiveness is reversible once operations cease. Overall, Project effects on short-eared owl nesting and foraging habitat will be not significant. The confidence in this prediction is rated as moderate.

18.2.4.2 Grizzly Bear and Wolverine

18.2.4.2.1 Health

The Project will result in a not significant effect on grizzly bear and wolverine health from exposure to COPC. The confidence in this prediction is rated as high.

18.3 COMBINED EFFECTS ON THE TERRESTRIAL ENVIRONMENT

Residual Project effects on permafrost conditions, terrain stability and landforms are predicted to be negligible and not significant. Residual effects on soil quality and quantity are assessed as negligible to low and not significant. Residual effects on vegetation abundance and community diversity and vegetation quality are rated as negligible to low and not significant. Residual effects on caribou and muskox are predicted to be negligible to low and not significant. Residual effects on raptors and to migratory birds will be moderate during construction, low during operation and negligible post operation. These effects are restricted to the Project footprint and ZOI and are assessed as not significant. The residual effects of the Project on species at risk is assessed low to negligible and not significant.

Overall effect of the Project on the terrestrial environment is assessed as not significant.

19 SUMMARY OF MITIGATION MEASURES FOR THE TERRESTRIAL ENVIRONMENT

19.1 TERRAIN, SOILS AND VEGETATION

19.1.1 Terrain

Effective mitigation strategies for effects on terrain will identify terrain types that may be susceptible to either terrain instability or thaw settlement or are important and sensitive landforms. By identifying specific locations of such terrain areas, effective mitigation measures can be tailored to address site-specific conditions.

Detailed mitigation measures will vary depending on local conditions and Project activities. Best construction and Project management practices with due consideration of the projected rate of climate warming coupled with recent engineering advances, especially in permafrost engineering, will be implemented to address any issues with changes in permafrost conditions, and terrain stability. Issues related to the surface disturbance to any challenging landforms will be best addressed by proper citing of Project facilities and associated infrastructure.

Design mitigation measures will include minimizing Project disturbance footprint and a number of drainage areas affected by the Project components and activities, and avoiding surface disturbance in high ground-ice areas and susceptible terrain and landforms to reduce potential for deepening thaw depth and associated thaw settlement and terrain stability. Discipline-specific mitigation will include the consideration of Project activities such as construction in permafrost sensitive areas during the winter (where feasible), controlled vehicular traffic along roads, planning of proper culvert location and construction and maintenance of roads susceptible to excessive groundwater seepage.

Additional mitigation measures that will reduce or eliminate potential Project effects on terrain include:

- sustain safe construction and operation practices within and adjacent to the Project footprint
- use coarser materials for road construction to minimize frost effects
- manage drainage around infrastructure to reduce deep pools of water at the surface
- insulate infrastructure, where feasible

- avoid or minimize susceptible terrain associated with high ground-ice content and fine- to medium-textured materials on sloping topography within the mine infrastructure area and along major road alignments
- avoid uncommon landforms like eskers, wetlands and shoreline areas during the design phase of Project
- minimize cut width or disturbance through eskers, wetlands and shoreline areas
- reduce the use of glaciofluvial landforms during mine infrastructure construction

Supplementary engineering field investigations prior to construction of mine infrastructure will provide information that will aid in refining terrain mitigation measures. Additional site-specific field investigations will be conducted to assess specific poorly drained areas and drainage condition, local variations in permafrost conditions (ground-ice content), terrain slope, and ground temperature prior to construction of mine infrastructure and roads.

19.1.2 Soils

19.1.2.1 Soil Quality

Air emissions that could cause soil acidification as well as changes in COPC concentrations within soils will occur throughout the duration of the Project. These effects will be minimized because emissions from all industrial machinery and equipment, including the diesel-powered generators will meet the federal air emission standards. Low sulphur diesel fuel will be used to reduce emissions associated with diesel fuel combustion. In addition, scrubbers will be installed on any mill stacks that emit particulates and contaminants (e.g., acid plant exhaust stack) to remove these items from the air stream before discharge.

Soil admixing will likely occur to varying degrees during topsoil stripping, as topsoil depth varies across the Project development area. To reduce soil admixing, AREVA environmental personnel will be on-site to work with construction crews during the stripping process to help identify areas where the topsoil layer has been adequately stripped to prevent further stripping at these locations. Stripped topsoil will be kept separate from subsoils stored at the overburden pile location to prevent soil admixing, as well as loss of the growth medium layer that will be used for reclamation purposes. Stripped topsoils will also be well-segregated from the ore piles and the Type III mine rock stockpiles to prevent soil contamination. Efforts will be made during the storage process to place frozen or wet soils removed during site preparation within drier soil materials of the same nature (i.e., topsoil, subsoil) to prevent potential migration and subsequent admixing with other soil or waste rock piles. The stripped topsoil and subsoil materials stored in the overburden pile location will be scanned in order for any radiation-contaminated soil to be removed and not used in reclamation.

Soils exposed during construction are susceptible to erosion from surface drainage and wind events. Soil erosion from surface drainage can occur as a result of 1) natural surface drainage from the surrounding area travelling over the Project footprint and 2) surface drainage from within the Project footprint caused by rain events. Freshwater diversion channels will be constructed to divert surface drainage around the Project footprint, thereby reducing the potential for on-site erosion. Riprap armouring overlying a geotextile will be placed on the channel bottom and side slopes of the diversion channels to mitigate potential erosion of the channel (see Tier 3, Appendix 2E). Other erosion control structures (e.g., sediment breakers, wattles) may also be placed within the diversion channels following initial excavation to reduce the amount of soil erosion by flowing water until vegetation has established or a geotextile liner is placed within the channel. Culverts will be installed where the proposed all-season road crosses natural drainage patterns to facilitate water movement, and in a manner that will prevent scouring of the tundra environment at the culvert outflow location.

Site containment will involve sloping the site pads towards the runoff ponds. However, during construction and prior to site containment, disturbed soils may be susceptible to erosion from surface drainage within the Project footprint caused by precipitation events and snowmelt. If the disturbed areas are deemed to be susceptible to erosion prior to development of site containment, temporary erosion control structures (e.g., silt fences) will be placed on the downslope side of the Project footprint to capture and filter sediment-laden runoff.

Erosion of soils stored in the overburden pile will be monitored throughout the duration of the Project. If climatic events (e.g., precipitation, wind) cause excessive soil erosion from the overburden piles, AREVA will apply mitigation (e.g., the application of a soil tackifier) to the overburden piles to prevent further erosion.

Soil compaction will occur through the duration of the Project due to the movement of vehicles on roads and site pads, as well as placement of infrastructure (e.g., mine plant, accommodations complex). During final closure, areas ready for reclamation will be scarified to loosen compacted soils, allowing for increased success rates of seed germination and sprouting of propagules within the areas being reclaimed. Vehicle travel along the winter roads will likely not cause soil compaction because traffic will occur during frozen ground conditions. However, rutting may occur in localized spots where the integrity of the winter road may be compromised. Efforts to identify and avoid vehicle travel on soft spots along the winter road will be employed. Rig matting may also be used to prevent rutting and other disturbances to soils where the winter road's integrity is compromised.

Dust will be created during mining and movement of materials to either the ore piles or waste rock piles. During open pit mining, blasting patterns will be used to control the dispersion of materials as well as dust. Where possible, blasting may also be avoided on days where dust dispersion outside of the Project footprint is anticipated to be excessive due to the prevailing winds speeds. Dust suppression will involve spraying water from a tanker truck affixed with either a spray nozzle or spray bar onto dust-prone areas. If water spraying is not effective in preventing dust occurrence, an adaptive management strategy focussing on additional dust

suppression techniques will be investigated, such as using a dust suppressant identified in the GN (2002) guidelines. Speed limits around the mine site and along all roads will be strictly adhered to, to reduce airborne dust from vehicular and other equipment traffic.

19.1.2.2 Soil Quantity

Best management practices will occur during construction of the Project. Construction activities will likely be postponed during large precipitation events to prevent excessive disturbance to vegetation and soils due to wet working conditions.

During topsoil stripping, efforts will be made to reduce the movement of stripped topsoil when transferring to the overburden pile. For example, topsoil stripped at the far end of the construction area will likely be hauled to the overburden pile using carrying equipment (e.g., buggy scrapers, dump truck) rather than pushing the stripped topsoil to the overburden pile using a bulldozer or grader. This will help prevent soil loss from movement of disturbed soils over the work area.

Preventing soil loss caused by soil movement during the construction phase is important for conserving enough of the growth medium layer for future reclamation purposes. Prior to commencing construction activities, a construction plan for topsoil stripping will be developed based on the topography and terrain features at the proposed mine sites and dock facility. This plan will help determine where stripping will occur, the direction of travel when stripping, taking into consideration terrain features and topography to prevent loss of stripped topsoil as well as where stripped topsoils will be placed. If possible, stripped topsoils will be pushed towards the proposed overburden pile location. Temporary overburden piles may be required in areas where terrain features or topography prevent pushing stripped materials to the overburden pile without causing substantial loss of stripped materials. In these instances, stripped materials will be transported from the temporary overburden piles in either a buggy scraper or dump truck to the final overburden pile location.

Soil burial during development of the roads and airstrip will be confined to the boundaries established from the detailed design for these components. Soil erosion during construction activities has the potential to occur where topsoil stripping or other disturbances to soils have occurred.

19.1.3 Vegetation

19.1.3.1 Vegetation Quantity

Pre-construction surveys will be completed of the surveyed Project footprint boundaries for listed species to confirm their absence from the area to be disturbed. If any listed species are observed, a number of mitigation measures may be employed. For any listed species observed along the proposed access roads, efforts will be made to re-route the access to avoid disturbing

the listed species. If listed species are observed within the proposed mine sites or dock facility, AREVA will consult with the GN regarding transplanting the listed species to another suitable location.

Best management practices will occur during construction of the Project. Construction activities will likely be postponed during large precipitation events to prevent excessive disturbance to vegetation and soils due to wet working conditions.

Site clearing and vegetation burial will occur within the confines of the Project footprint to reduce the potential for additional vegetation loss and prevent unnecessary disturbance to vegetation adjacent to the Project development area. The work area boundaries will be clearly identified by markers placed along the perimeter during construction to reduce vegetation damage and disturbance.

During topsoil stripping and stockpiling, the vegetation seedbank will also be preserved. Preservation of this seedbank will provide seeds and propagules during soil replacement, facilitating natural regeneration of native vegetation to reclaimed areas.

The proposed routing of the winter roads makes use of waterbodies (e.g., lakes) and watercourses (e.g., streams) as much as possible. Rugged microtopography will be avoided, where practical, along the proposed winter access road to reduce the amount of granular material required for creating a level travel surface that would cause vegetation burial. Rig matting may also be used in areas where the use of granular material is not practical to prevent damage to the underlying vegetation along the winter road.

To prevent the introduction of invasive and/or non-native vegetation to the Project area, all equipment and machinery will be cleaned of foreign particles (e.g., soil, thatch) prior to initial transport to the Project (i.e., prior to loading onto the barge, or shipping by air). All equipment and machinery will be further inspected for foreign particles upon arriving at either the dock facility or while being off-loaded at the airstrip. Any foreign particles found on equipment and machinery will be removed, collected, and incinerated to prevent propagule establishment and proliferation.

Progressive reclamation will occur throughout the Project on decommissioned areas to return disturbed areas to a natural state. Adaptive management strategies based on the most recent research and literature pertaining to reclamation of disturbed areas in arctic environments will be implemented and monitored for succession and to assess whether further reclamation efforts are necessary.

19.1.3.2 Vegetation Quality

Air emissions that could adversely affect vegetation quality will occur throughout the duration of the Project. To reduce the effects of air emissions on vegetation, all industrial machinery and equipment and diesel-powered generators will meet the federal air emission standards. Low sulphur diesel fuel will be used to reduce SO_2 fumigation. The acid plant will be the largest producing unit of SO_2 associated with the Project. As such, a scrubber will be installed on the exhaust stack to remove particulates, acid mist and excess SO_2.

Dust will be created due to Project activities such as blasting, hauling of ore and waste rock materials from the mine pits, as well as vehicular traffic along the access roads, During the detailed design of the roads, efforts will be made to use non-calcareous materials from quarry sites to minimize dust-prone aggregate from being used during road construction. During open pit mining, blasting patterns will be used to control the dispersion of materials as well as dust. Where possible, blasting may also be avoided on days where dust dispersion outside of the Project footprint is anticipated to be excessive due to the prevailing winds speeds. Dust suppression will involve spraying water from a tanker truck affixed with either a spray nozzle or spray bar onto dust-prone areas. If water spraying is not effective in preventing dust occurrence, an adaptive management strategy focussing on additional dust suppression techniques will be investigated, such as using a dust suppressant identified in the GN (2002) guidelines. Speed limits around the mine site and along all roads will be strictly adhered to, to reduce airborne dust from vehicular and other equipment traffic.

19.2 TERRESTRIAL WILDLIFE

19.2.1 Caribou and Muskox

19.2.1.1 Mortality

Mitigation of potential increased mortality risk will involve AREVA and other parties such as the Baker Lake HTO and GN for harvest management and population assessment. AREVA is confident in the implementation of measures such as road closures, private access, or limits to seasonal use if the winter road option is selected. Several effective mitigation options that AREVA can implement independently are described in Section 13.3.2.5.1 (Mitigation by AREVA). This can include future industrial users of an all-season winter access road to adopt the Project's road use policy, agreements with the HTO/KIA that they will abide by road traffic restrictions, and other potential agreements as described in Section 13.3.2.5.2 (Mitigation by AREVA and Others).

Wildlife harvest is regulated by the GN. The GN's Caribou Strategy Framework identifies a number of actions oriented towards working with industry, HTOs and other management partners to support harvest management (described in Section 13.3.2.5.3 – Mitigation by Other Organizations and Agencies). The management of potential over harvest of caribou is beyond the control of the Project and ultimately is the responsibility of the GN and its wildlife co-management partners.

There are a number of mitigation tools available to AREVA, resource users (e.g., HTO, KIA), and the management authority of the GN that should be effective at mitigating potential caribou harvest. An all-season access road from Baker Lake to a mine site is not expected to be a trigger of concern for potential overharvest of Qamanirjuaq or Baker Lake caribou.

19.2.1.2 Habitat

The Kiggavik Project will mitigate potential adverse effects on wildlife habitat by:

- minimizing the Project footprint
- minimizing Project activities outside of the footprint
- reducing road activity during important seasonal migratory seasons and during post-calving
- progressively reclaiming disturbed areas
- providing dust suppression along roads during dry summer periods
- eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings

In the case of the winter road options, reducing the Project footprint will mitigate habitat loss and reduce the likelihood of the Project acting cumulatively with other projects in the Kivalliq region.

19.2.1.3 Movement

The Project will mitigate effects on wildlife movement by:

- reducing road embankment height of the North All-Season Road
- snow management that avoids long continuous cuts or piles of snow that could restrict spring migration across roadways
- reducing leg entrapment risk to caribou during fall migration by constructing roads from finer material
- avoiding construction activities within 10 km of designated water crossings during 15 May to 1 September, in accordance with the DIAND Caribou Protection Measures

- minimizing the use of fencing and, where required, minimizing the lengths of fencing unless required for safety
- implementing temporary road shutdowns if large numbers of caribou are observed migrating through the area

The DIAND Caribou Protection Measures are intended to mitigate potential Project effects. The measures include protection for caribou during the calving and post-calving seasons, 15 May to 1 September. During this period, the caribou protection measures restrict construction of camps, fuel caching or blasting within 10 km of crossings and diamond drilling within 5 km of crossings. Also, the protection measures state the Project cannot "block or cause substantial diversion to migration" and will "cease activities that may interfere with migration".

19.2.1.4 Health

Design aspects, operational measures and other mitigation measures have been incorporated into the current Project design, which will minimize Project-associated emissions and/or the potential effect of Project-related emissions. These have been discussed in the Atmospheric Environment report (Tier 2, Volume 4) and the Aquatic Environment report (Tier 2, Volume 5) in more detail.

19.2.2 Raptors

19.2.2.1 Habitat Availability

AREVA will mitigate potential adverse effects on raptor habitat through:

- minimizing the Project footprint
- minimizing Project activities outside of the footprint
- progressively reclaiming disturbed areas
- providing dust suppression along roads during dry summer periods to reduce disturbance to nests adjacent to the North All-Season Road corridor
- eliminating dust dispersal from the tailings management facility through subaqueous deposition of tailings
- in the case of the winter road options, reducing the Project footprint will mitigate habitat loss and reduce the likelihood of the Project acting cumulatively with other Projects in the Kivalliq region

19.2.2.2 Nest Productivity

Nesting pairs are most likely to be disturbed during Project construction if the North All-Season Road is constructed. Key mitigation measures include the following during the construction period:

- restricting blasting activities (for road construction) within 3 km of a known nest site to outside of the territory occupancy and nesting season (about mid-May through to end of August)
- restricting land-based activities within a 3 km radius of active nest sites during the nesting season
- developing a nest-site specific construction mitigation plan which will include territory activity monitoring when construction is occurring within 3 km of a known nest site

The bulk of the disturbance to nesting pairs is expected to have occurred during the construction period. Mitigation during operations can include:

- no on-ground visits to active nest sites by Kiggavik employees
- no overflights of known nest sites

19.2.2.3 Health

Mitigation measures for the effects of the Project on the heatlh of raptors is described in Section 14.2.3.4.

19.2.3 Migratory Birds

Mitigation measures for migratory birds habitat availability and health will be the same at those described for raptors (Section 14.2.1.4 and Section 14.5).

19.2.4 Species at Risk

19.2.4.1 Habitat Availability

Mitigation measures that will be implemented to minimize effects on habitat availability for short-eared owls include the following:

- If possible, construction activities involving site clearing will be scheduled to occur outside of the breeding and nesting period for migratory birds (i.e., May to July).
- Site clearing and any other disturbances to the landscape will be kept within the confines of the pre-surveyed Project Footprint boundaries.

- Prior to clearing activities during the breeding bird season, all areas within the construction area will be searched for nests. Active nests will be identified and for short-eared owl, an 800 m radius no-disturbance buffer will be applied until nesting is complete and chicks have fledged.
- All on-site observations of short-eared owl will be investigated to determine presence of nests sites. Active nests will be marked as described above with an 800 m radius no-disturbance buffer.
- Reclamation will include the establishment of shrub cover which will provide small mammal (prey) habitat and potential nesting habitat.

19.2.4.2 Health

Mitigation measures for the effects of the Project on the heatlh of grizzly bears and wolverine is described in Section 16.2.1.4 and Section 16.6.

20 SUMMARY OF MONITORING FOR THE TERRESTRIAL ENVIRONMENT

20.1 TERRAIN, SOILS AND VEGETATION

20.1.1 Terrain

While the implementation of mitigation strategies is critical to reducing any effects on terrain, it is equally important to complete regular and routine monitoring to ensure that effects are minimized and to identify where new mitigation measures may be required. Monitoring will begin upon construction and will continue through the duration of the Project.

A key consideration in design of the monitoring programs is that the environment is expected to change independent of the Project as a result of climate change. For the most part, visual monitoring will suffice as it will be important to visually observe any changes (e.g., accelerated solifluction, groundwater seepage, erosion). In some cases, especially on steeper slopes, slope monitoring devices will be used for the duration of the Project. Similarly, thermistors will be installed at key sites to determine and monitor the rate of change in ground temperature. Special devices will also be installed to record maximum thaw penetration and maximum ground-surface movement at thaw depth monitoring sites. While such devices are not required extensively throughout the Project footprint, a number of permanent monitoring plots will be established at the outset of the Project to monitor any effects of climate change and hence the overall change in the natural landscape. Laboratory analysis of soil samples will be conducted, which will help to determine geotechnical parameters such as total moisture content, frozen bulk density and ground-ice content. These parameters will be used to calculate thaw strains, which are used to determine the thaw settlement resulting from the simulated increase in thaw depth at the each sampling site.

20.1.2 Soils

20.1.2.1 Soil Quality

Soil quality will be monitored throughout the duration of the Project. Air emissions and dust deposition monitoring will be a component of soil quality monitoring. Chemical analyses of soil samples from permanent sample plots located within the mine LAA (i.e., exposure plots) and within the RAA (i.e., reference plots) will occur, and comparisons will be made to air emission and dust deposition results, as well as to the baseline values and CCME guidelines. The overburden piles will be routinely checked for erosion, and mitigation measures will be implemented if issues are identified. The winter road will be monitored during use for structural

integrity to avoid rutting and/or damage to the underlying soils, and mitigation will be applied to areas of concern. The North All-Season Road will also be monitored for structural integrity and the effectiveness of dust suppression techniques, as well as the effectiveness of culverts for allowing surface drainage while preventing soil scouring.

20.1.2.2 Soil Quantity

Soil quantity will be monitored primarily during the construction phase of the Project, as well as when any earthwork involving the removal or placement of topsoil is required. An environmental monitor will likely be on-site during the construction phase to assist AREVA personnel and contractors with mitigation strategies to reduce the effects of the Project on soil quantity, such as topsoil stripping, soil storage, and soil erosion on disturbed areas. Dust deposition monitoring will occur throughout the duration of the Project to identify and mitigate potential effects.

20.1.3 Vegetation

20.1.3.1 Vegetation Quantity

An environmental monitor will be on-site during all phases of the Project to work with AREVA personnel and contractors to meet and comply with environmental regulations associated with vegetation.

Throughout the duration of the Project, monitoring for invasive species will be conducted. Any invasive species identified adjacent to the Project footprint will be documented. If invasive species are identified as noxious weeds, or other vegetation species that are suspected of competing with native vegetation, efforts will be made to remove these occurrences to prevent a spread or proliferation of these invasive species.

Measurements of dust deposition from snow survey stations and dust gauges placed around the Project Footprint and along the proposed access roads will be taken prior to construction activities. Permanent sampling plots to monitoring vegetation abundance and community diversity will also be established around the Project Footprint and adjacent to the proposed access roads prior to their construction. These permanent sampling plots will be routinely surveyed and assessed to measure potential changes in vegetation abundance and community diversity. Results from dust deposition monitoring and the vegetation community monitoring will inform on the effectiveness of mitigation, and whether further actions are required.

20.1.3.2 Vegetation Quality

Vegetation monitoring will occur throughout the duration of the Project, along with air emissions and dust deposition to evaluate their effects on vegetation quality. Vegetation quality monitoring will involve collection of vegetation samples from permanent sample plots located within the predicted exposure areas as determined by the isopleths for PAI and TSP within mine LAA (i.e.,

exposure plots), as well as reference plots located within the Project RAA. Chemical analyses of the vegetation samples will be completed and comparisons will be made between the reference and exposure site values, as well as to the baseline values and CCME guidelines.

A dust monitoring program will be implemented, the results of which will be used to confirm if effects are occurring on vegetation and modify management strategies, if necessary.

20.2 TERRESTRIAL WILDLIFE

20.2.1 Caribou and Muskox

20.2.1.1 Mortality

Compliance and environmental monitoring for change in mortality to caribou and muskox includes the following:

- continue HHS (helps to determine total harvest by herd)
- continue participation in the GN-led Caribou Collaring Program (determine seasonal distribution by herd)
- support GN-led herd delimitation and population estimate survey (determine regional herd population trends)
- continue Project-specific caribou monitoring programs (ground-based observations)

20.2.1.2 Habitat

AREVA will monitor the Project footprint on an annual basis to assess the footprint area for changes in habitat availability. This applies to the assessment of terrestrial wildlife, raptors, migratory birds, and species at risk. Continued contributions to a Government led caribou collaring program will provide future information on the response of caribou to habitat disturbance in the Kivalliq region.

20.2.1.3 Movement

AREVA will conduct the following monitoring for change in movement of caribou and muskox:

- continued contributions to a government-led caribou collaring program
- monitoring caribou use of water crossings located within 10 km of the Project
- seasonal monitoring of caribou movement prior to caribou entering the RAA as a proactive way of providing information that will advise temporary shutdown of traffic on roads

20.2.1.4 Health

No specific monitoring requirements are recommended based on the assessment for change in health of caribou and muskox, raptors, migratory birds, or species at risk. The monitoring of other environmental components (e.g. water, vegetation — specifically lichen) will provide valuable information for confirming the results of the assessment.

20.2.2 Raptors

20.2.2.1 Nest Productivity

Monitoring for change in raptor nest productivity will include:

- individual nest site monitoring during construction to determine when territorial pairs are attempting to establish a territory and begin nesting
- annual monitoring of territory occupancy, egg laying, egg hatching, and chick

21 REFERENCES

CCME (Canadian Council of Ministers of the Environment). 2009. Soil quality guidelines for the protection of environmental and human health. Available at: http://st-ts.ccme.ca/. Accessed October 3, 2011.

Government of Nunavut (GN). 2002. Environmental guideline for dust suppression. Available at: http://env.gov.nu.ca/node/82#Guideline Documents. Accessed: October 3, 2011.