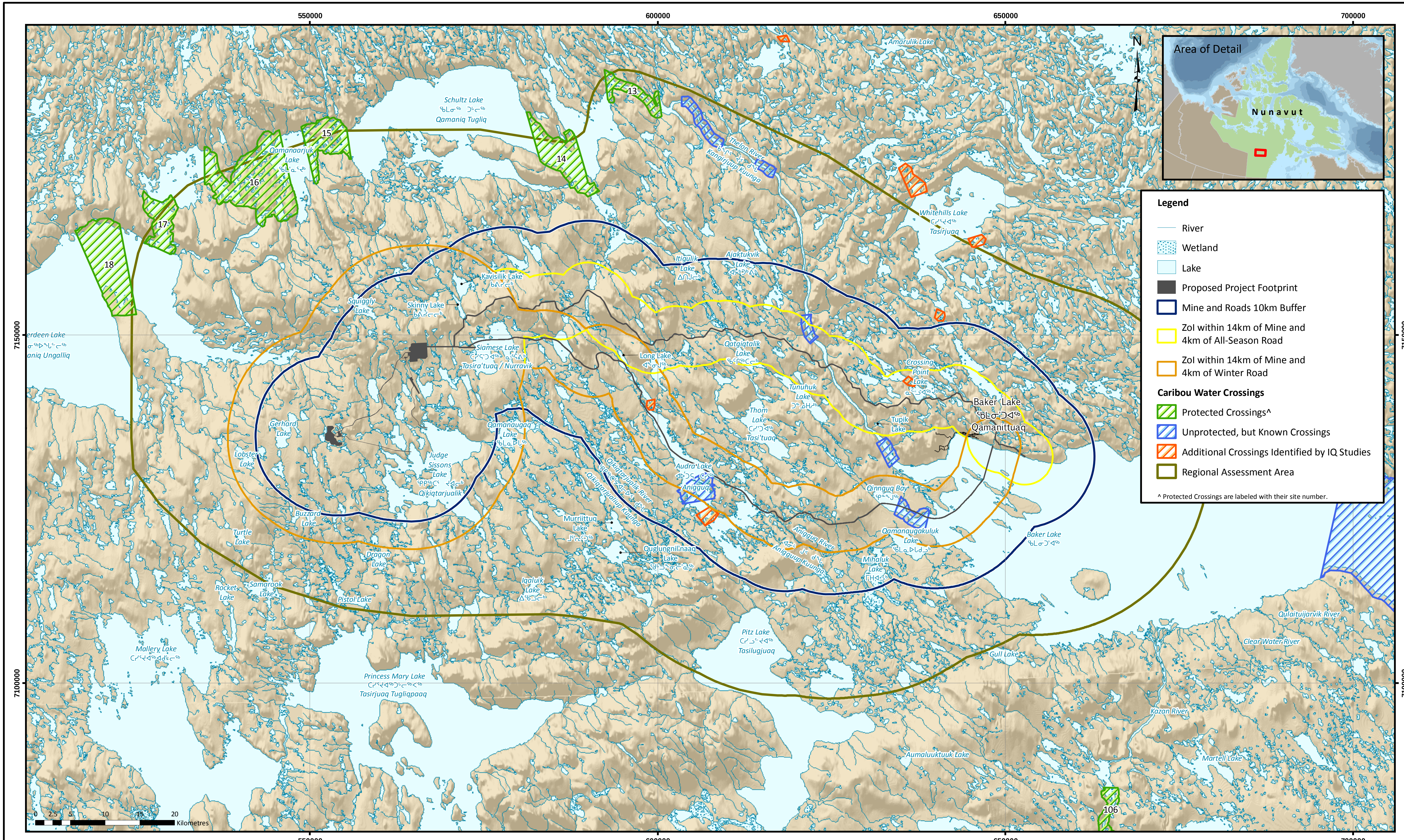

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 09/18/2014 Scale: 1:500,000
File: 13.2-17_Caribou_Water_Crossings_All-Season_Winter_Rds.mxd
Data Sources: *Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., Dept. of Indian & Northern Affairs, Canadian Wildlife Service, Gebauer & Associates.*

FIGURE 13.2-18
CARIBOU WATER CROSSINGS WITHIN 10KM OF THE MINE, ALL-SEASON ROAD, AND WINTER ROAD FOOTPRINTS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 6

Kiggavik Project
AREVA

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Table 13.2-15 Summary of Caribou Water Crossing Known to Occur within 10 km of the Mine and Winter Road Footprint

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

13.2.3.6 Determination of Significance for Change in Movement

Potential Project effects on caribou movement are difficult to predict and quantify. No literature or studies are available that provide quantitative thresholds on movement effects, and there is little empirical evidence of effects on direction or more localized caribou movements in response to northern mining projects. Given the variability in movements of the herd near the Kiggavik Project among seasons, years, herds, and individuals, assessing movement and predicting change is inherently uncertain.

Within the site-specific context of the Project, the determination of significance of potential Project effects on caribou movement considered several factors about caribou movement. First, an assessment of the likelihood that the Project and the potential ZOIs are within migration corridors was important to address to determine if the Project would cause a major diversion in long-established movement corridors. Movement was assessed by baseline studies that included a review of historical mapping and IQ knowledge about caribou movement through the region, and a review of potential encounter and residency rates using available collared female caribou location data. Second, an assessment of the location of water crossings in proximity to the mine and road footprint and within the potential ZOI was important to determine interaction with site-specific topographical features important for movement. That assessment was made by reviewing water crossings identified by historical research, current harvester knowledge, and IQ. Third, the potential disturbance effects on more localized, non-migratory movements was assessed by considering the potential encounter and residency rates of caribou within the Project ZOIs.

With respect to significance determination of the potential Project effects on movement, the following magnitude ratings categories were considered:

- **Low (L)**: Project infrastructure and ZOI located outside of known migratory corridors and infrastructure located >10 km of known water crossings.
- **Medium (M)**: Project infrastructure located within 10 km of known water crossings and/or infrastructure and ZOI infringes on migratory corridors designated low to medium use (low/medium use quantified in the Kivalliq Atlas or identified by IQ).
- **High (H)**: Project infrastructure and ZOI located within 5 km of known water crossings, infringes on migratory corridors designation moderate to high use (it was assumed this would result in >10% of caribou not arriving at the calving grounds).

The Project is not known to be within a migratory pathway, identified both through historical research and through the IQ provided to the assessment. The known water crossings within 10 km of project infrastructure are identified because of their proximity to the road options. Although regular road traffic is not specifically identified as an activity for restriction within the DIAND Caribou Protection Measures, AREVA can limit road traffic if those crossings are being used by caribou during migratory movements. Project effects on localized movements can be addressed by cautious road operations where wildlife have the right-of-way and any number of the mitigation measures identified in Section 13.2.3.4 (Mitigation Measures for Movement), or in the Wildlife Mitigation and Monitoring Plan.

The Project's effects on caribou migration will be 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 Project area. 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. Statements made by IQ holders and the encounter and residency rates suggest that there will be year-to-year and herd differences in movement through time.

The conclusions from this assessment were adopted by the socio-economic assessment (FEIS Volume 9, Part 1, Socio-Economic Environment, Section 9.1.2 Harvesting). Access to caribou considers features such as travel routes available for hunters to reach animals, opportunities to hunt and people's decisions to take advantage of those opportunities. Changes to caribou distribution could influence local harvesting; however, given that the Project effects on caribou are assessed as being not significant, distribution is not considered to be an important determinant of access in the socioeconomic assessment on harvesting. Maintaining the long-term viability of caribou populations will provide opportunities future generations of local harvesters to hunt caribou.

13.2.3.7 Summary of Project Residual Environmental Effects for Change in Movement

It is likely that the Project will have a not significant effect on caribou movement. There may be some very localized effects on caribou that approach Project infrastructure. Although numbers of caribou may be found in the area at various times, and those numbers could be variable over the life of the Project, there is no indication that the Project intersects key migratory routes. Encounter rates and residency times of female collared caribou have been low within the Project's potential ZOI. Mitigation options are available to AREVA to directly mitigate caribou interaction with the Project, namely the wildlife decision matrix provided in the WMMP (Appendix 6D). There are no water crossings within the footprint of the Project, and caribou using water crossings through the life of the Project are protected by mitigation suggested in the Caribou Protection Measures. Monitoring of caribou movements and interaction with infrastructure is readily monitored. Table 13.2-16 summarizes the residual environmental effects of the Project on change in movement of caribou and muskox.

There is some uncertainty associated with the conclusion about Project effects on caribou movement. Although IQ information generally agrees with the available data that the area is not associated with key caribou movements, the survey and collar data is limited to only a few surveys upon which the encounter and residency rates were based.

Table 13.2-16 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 — All-Season Road Option												
Construction, Operation, Final Closure	Temporary road closures, road design, snow management	N	M	L	MT	C	R	U	N	N/A	M	Continued monitoring (collar studies)
Change in Caribou and Muskox Movement — Winter Road Option												
Construction, Operation, Final Closure	Temporary road closures	N	M	L	ST	R	R	U	N	N/A	M	Continued monitoring (collar studies)

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

13.2.3.8 Compliance and Environmental Monitoring for Change in Movement

AREVA will conduct the following monitoring activities to evaluate possible 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
- monitor the effects of road infrastructure and operations on caribou movements through seasonal track surveys for the first 3–5 years of operation in key movement areas.
- 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.

13.2.4 Assessment of Change in Health

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 was 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 by 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 (discussed in Tier 2, Volume 4) and water quality modelling (discussed in 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 lichen have a long life and the concentration can increase over time.

The intake of COPC by wildlife can then be 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, a conservative scenario was used in the assessment. It is assumed some caribou may spend 1.1% of their time in the LAA while other caribou may spend 4.7% 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 that 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 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; this value was used in the assessment for consistency with N288.6 (CSA 2012). 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 (2.7 mGy/d).

The bounding scenario carried through the ecological assessment was 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 as these constituents are present naturally in the environment. Concentrations of COPC in caribou tissue were measured as a component of the Ecological Risk Assessment. This baseline information is presented in Appendix 6C and summarized in Tier 3, Appendix 8A, Tables 3.2-16 and 3.2-17.

13.2.4.3 Effect Mechanism and Linkages for Change in Health

Changes in the health of caribou and muskox can occur if they are exposed to COPC at levels that are associated with an effect. As it is important that the populations are maintained, the potential for COPC to affect the growth and reproduction of these wildlife is examined. 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 were 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 incorporated into the current Project plans that will minimize Project-associated emissions and/or the potential effect of Project-related emissions.

The Air Quality Monitoring and Mitigation Plan (Tier 3, Appendix 4C) 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 were 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 are found in Volume 2

13.2.4.5 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 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 was 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 was selected as the conservative default benchmark for the ecological receptor. The Ecological and Human Health Risk Assessment report (i.e., 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 13.2-17 for caribou and Table 13.2-18 for muskox.

Table 13.2-17 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	0.013	0.015	0.014
Cobalt	0.001	0.001	0.001
Copper	0.094	0.094	0.094
Lead	0.002	0.002	0.002
Molybdenum	0.002	0.002	0.002
Nickel	0.007	0.007	0.007
Selenium	0.032	0.032	0.032
Uranium	<0.001	<0.001	<0.001
Zinc	0.025	0.025	0.025
Radioactivity	<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 10 and compared to a benchmark of 2.7 mGy/d

Details of calculation as well as additional results are provided in Tier 3, Appendix 8A

Table 13.2-18 Screening Index Values for Muskox

COPC	Screening Index (SI)		
	Baseline	Muskox Present in the LAAat Judge Sisson Lake in the Vicinity of the Kiggavik WTP Discharge	Muskox Present in the LAA at Judge Sisson Lake in the Vicinity of the Sissons WTP Discharge
Arsenic	0.001	0.001	0.001
Cadmium	0.034	0.034	0.034
Cobalt	0.002	0.002	0.002
Copper	0.322	0.322	0.322
Lead	0.002	0.002	0.002
Molybdenum	0.009	0.009	0.009

Table 13.2-18 Screening Index Values for Muskox

COPC	Screening Index (SI)		
	Baseline	Muskox Present in the LAAat Judge Sisson Lake in the Vicinity of the Kiggavik WTP Discharge	Muskox Present in the LAA at Judge Sisson Lake in the Vicinity of the Sissons WTP Discharge
Nickel	0.014	0.014	0.014
Selenium	0.007	0.007	0.007
Uranium	<0.001	<0.001	<0.001
Zinc	0.158	0.158	0.158
Radioactivity	<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 10 and compared to a benchmark of 2.7 mGy/d

Details of calculation as well as additional results are provided in Tier 3, Appendix 8A

With the potential exception of cadmium exposure to caribou, there is not expected to be any change from baseline. Overall, 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

As 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, vegetation [i.e., lichen]) will provide valuable information for confirming the results of the assessment.

13.3 Cumulative Effects Assessment for Caribou and Muskox

The assessment of the Project's cumulative effects on caribou habitat, movement mortality and health (energetics) follow methods similar to those used for other northern mining projects that assessed cumulative effects on barren ground caribou. Those projects include the Environmental Impact Statement for the Gahcho Kué Project (De Beers Canada Inc. 2010a), the Draft Environmental Impact statement for the Back River Project (Rescan 2013), and in the Final Environmental Impact Statement for the Meliadine Project (Golder Associates Ltd. 2014). Several other relevant projects were reviewed for cumulative effects methods and conclusions including the operating Meadowbank mine's Environmental Impact Statement (Cumberland Resources Ltd. 2005), and a review of effects of development on caribou from the perspective of an ecological model and IQ submitted to the Kugluktuk Hunters and Trappers Organization (Golder Associates Ltd. 2011). Those assessments collectively considered project-specific and cumulative effects on caribou from the Beverly, Qamanirjuaq, Ahiak, Wager Bay, and Bathurst herds.

The assessment for the Kiggavik Project incorporates some of the more useful methods used in those other assessments, and includes an assessment of the project and cumulative effects on seasonal habitat, movement and mortality. The assessment considers potential caribou exposure to cumulative project footprints (e.g., loss of habitat), to sensory disturbances (e.g., to development ZOIs), and potential increased mortality risk. Based on those results, the assessment incorporates an advanced assessment of project and cumulative effects on caribou energy-protein and population modeling of the Qamanirjuaq caribou (Attachment A). A summary of the cumulative effects methods and results from other similar projects noted previously are presented to provide a perspective on the approach taken for the Kiggavik Project's caribou cumulative effects assessment.

13.3.1 Comparative Projects Effects Assessments Overview

Meadowbank Project Caribou Cumulative Effects (Cumberland Resources Ltd. 2005)

The Meadowbank Gold Project is located in the Kivalliq region approximately 70 km north of the Hamlet of Baker Lake. Exploration began in 1995, and the mine has been producing gold since 2010, with mine life expected through 2017 (Agnico Eagle Mines 2013).

Individual caribou from several herds were known to occur in the Meadowbank area, including Ahiak, Beverly, Qamanirjuaq and Wager Bay (Cumberland Resources Ltd. 2005).The project's Final Environmental Impact Statement (FEIS) included a cumulative effects assessment, including an assessment of caribou. The assessment considered mineral exploration, mines and mining projects, and the hamlet of Baker Lake as disturbances in the study area that included the outer geographical extent of the annual range of the caribou populations from which individual animals that potentially use the Meadowbank project area could originate (i.e., a large portion of mainland Nunavut). The assessment considered cumulative effects on caribou habitat, movement and energetics, and mortality risk. The quantitative conclusion for habitat was that the cumulative total habitat loss due to project footprints was a very small fraction of the total area occupied by the herds. The qualitative conclusion about cumulative effects on movement and energetics included a discussion about the fact that the Meadowbank mine is known to not be in a major migration corridor and included a review of modelling from the Diavik project that is known to be in a movement corridor for another herd of barren-ground caribou. The qualitative assessment of mortality risk included the statement "…*it is anticipated that effects of increased access as a result of the all-weather road will change the spatial distribution of hunter kills, rather than substantially increase the total number of kills (i.e., more kills may occur closer to the road, but overall numbers of animals killed will remain similar to present numbers)*," and that the effect would persist through the life of that project. That cumulative effect assessment did not consider the Kiggavik project.

Gahcho Kué Project (De Beers Canada Inc. 2010a)

The Gahcho Kué Project is a proposed open pit diamond mine project located at Kennady Lake, approximately 300 kilometres northeast of Yellowknife and 90 kilometres east of De Beers' Snap Lake diamond mine. The environmental review was completed in 2012, construction started in December 2013, and production is expected to begin in 2016 (Mountain Province Diamonds 2012).

The project may interact with caribou from the Bathurst and Ahiak herds (De Beers Canada Inc. 2010b). Cumulative effects assessed included 1) direct habitat loss and fragmentation from development footprints (including winter roads); 2) indirect changes to habitat quality from sensory disturbance; 3) assessed using population models, 4) an energetic model, and 5) an assessment of traditional and non-traditional uses were also examined within the annual home range of each herd.

1. The cumulative direct disturbance to the landscape from the cumulative previous, existing, and future developments was predicted to be less than or equal to 1.7% of the Bathurst and Ahiak caribou herds seasonal ranges relative to reference conditions. The cumulative impact on habitat fragmentation from a winter access road was predicted be <1.7% in either the Bathurst or Ahiak ranges.
2. Indirect changes to habitat quality from sensory disturbance (i.e., ZOI) are expected to result in a low magnitude cumulative decline in preferred habitat across seasonal ranges of the Bathurst and Ahiak caribou herds (ranged from 1.1% to 7.3% — further analyses showed loss of preferred habitat had no statistical effect on population abundance and persistence of caribou).
3. Population models predicted that the incremental impacts from the Project and the Taltson Hydroelectric Expansion Project had little influence on the persistence of the caribou herd relative to reference conditions. Specifically, the relative decrease in modelled final abundance was 1.5%. Modelled cumulative changes in habitat and fecundity resulted in a 12.2% reduction in projected final herd abundance relative to reference conditions.

4. Energetic and population model results indicated that insect harassment and harvest levels had stronger effects on caribou populations relative to the cumulative changes resulting from development disturbances. For a summer with average insect harassment levels, De Beers Canada Inc. (2010b) determined that almost 500 disturbance events would be required before a female lost sufficient weight to result in failed reproduction the following year. Further, a spatial examination of existing satellite collar data from 1996 to 2009 showed that caribou encountered relatively few ZOIs during summer and fall movements. Based on past, present and future cumulative development predictions, a typical Ahiak or Bathurst caribou may encounter approximately 19 disturbance events during summer to fall movements.
5. Based on evidence, analyses and modelling, De Beers Canada Inc. (2010b) concluded that cumulative disturbances should be reversible and not significantly affect the future persistence of caribou populations. Subsequently, cumulative impacts from development were predicted to have a not significant adverse effect on continued opportunities for use of caribou by people.

Effects of Development on Barren-ground Caribou: Insight from IQ and an Ecological Model (Golder Associates Ltd. 2011)

This report summarizes an approach to quantifying Bathurst caribou encounter and residency rates identical to those used by the same authors for the Gahcho Kué Project with similar results. The difference in that report is that comparisons were made between those results to information provided through IQ interviews and meetings. The summary integrated conclusions about cumulative disturbances to caribou derived from the ecological model and IQ. There was general agreement that mineral development effects may not be having as much of an effect on caribou behaviour as climate change and insect harassment. There was some disagreement among interviewees about the magnitude of effect that human disturbance is having on caribou. Both the IQ and the modeling approach highlighted the difficulties of predicting effects on caribou.

Back River Project (Rescan 2013)

The Back River Project is a gold exploration project in the Kitikmeot region of western Nunavut along the western shore of southern Bathurst Inlet. The Back River project's Draft Environmental Impact Statement (DEIS) submission summarized cumulative effects with the Bathurst caribou herd's combined post-calving and summer range, and the Beverly caribou herd's summer and winter (separate) ranges. The Back River Project's cumulative effects assessment evaluated 1) habitat loss, 2) disturbance, and 3) reduction in productivity.

1. Habitat loss was assessed by combining the estimated total habitat area removed by all project footprints, including the likely area degraded by dust and disturbance surrounding each project (i.e., ZOI). For the Beverly herd winter range, this included a habitat loss due

to winter roads. High quality habitat for the Beverly herd, where an RSF was not available, was estimated proportional to that available in the Project's RSA. The total habitat loss (including a 100 m radius degraded due to dust) in the post-calving and summer range of the Bathurst herd was 0.33%; 0.18% of the Beverly's summer range, and 0.13% of the Beverly's winter range (Rescan 2013, Section 5.6.2.1).

2. Disturbance was assessed by evaluating different disturbance buffer scenarios. The scenarios included 1.5 and 4 km disturbance buffers around all-season roads, a 200 m buffer around winter roads, and a 4 and 14 km disturbance buffer around active mines (Rescan 2013, Section 5.6.2.2). The assessment focused on high quality forage habitat measured either by the Bathurst herds RSF, or by the use of SRVI for the Beverly herd. For the Bathurst summer range the combined ZOIs, depending on which disturbance scenario is chosen, covers from 0.6 to 3.5% of available high quality forage during the summer (Rescan 2013, Table 5.6-5). For the Beverly herd, cumulative disturbance can range from 0.4 to 1.2% (winter) and 0.1 to 0.6% (winter) of available high quality forage habitat depending on disturbance scenario (Rescan 2013, Table 5.6-7).
3. Effects on productivity were assessed based on assumptions made about caribou exposure to disturbing activities (Rescan 2013 Section 5.6.3.2). GPS collar data were used to map the movement paths of females to calculate caribou encounter rates with active mine sites, mining exploration camps, and other developments. Assumptions were made including that presumed disturbed caribou experienced an energetic cost when encountering disturbances. Encounter rates were used to estimate decreases in the energetic balance of caribou resulting from additional movements and excitation, from which changes in productivity were predicted. Regardless of the methods, results were not clear.

Meliadine Project Caribou Cumulative Effects (Golder Associates Ltd. 2014)

The Meliadine project summarized cumulative effects within the Qamanirjuaq caribou herd's post-calving range — the Caribou Effects Study Area (CESA; Golder Associates Ltd. 2014, Sec. 6.1.1.3, pg. 6-5). The cumulative effects assessment focused on three primary pathways: 1) changes to habitat quantity and fragmentation; 2) changes to habitat quality, movement and behaviour; and 3) changes to survival and reproduction. The cumulative effects assessment of the Meliadine project included consideration of the Kiggavik Project in the calculation of cumulative effects of projects in the post-calving range of the Qamanirjuaq caribou.

1. To assess changes to habitat, the total area removed for projects (i.e., known and estimated project footprints) in the CESA was compared to baseline conditions using available ecological land classification classes. The cumulative effects assessment of that project concluded that the direct incremental and cumulative changes in land area developed in the CESA as a result of known and expected future developments were expected to be less than 0.5%. The cumulative effect to lichen tundra was a loss of 0.36% within the CESA (Golder Associates Ltd. 2014, Sec. 6.6.4.1.2).

2. To assess changes to habitat, quality and behaviour, hypothetical ZOIs were applied to projects in the CESA. Disturbance coefficients were associated with the various ZOIs and were used as multipliers of habitat quality reduction. For that analysis, the reduction in habitat quality was represented by a reduction in habitat quantity (Golder Associates Ltd. 2014, Sec. 6.6.4.2.1). Direct incremental and cumulative changes in area in the CESA as a result of known and expected future developments and their ZOI were expected to be less than 3.0% of the CESA (Golder Associates Ltd. 2014, Sec. 6.6.4.2.2).
3. The effects on survival and reproduction were assessed qualitatively through a literature review, existing IQ and interviews to determine potential for increased access for harvesting. The presumption is that increased harvester access may have a negative effect on the overall survival and reproduction of the Qamanirjuaq caribou herd. Specific results were not stated, but it was acknowledged that harvester access was likely due to public use of the all-weather road used to access the Meliadine mine site.

Similar to other project-specific and cumulative effects described above, the Kiggavik Project assessment follows a similar approach. For analytical purposes, the assessment relies on multi-year satellite collared female caribou location data, predicted ZOIs around likely disturbance activities, hypothetical disturbance responses, measures of effects on habitat, and ultimately the combined project and cumulative effects of multiple projects on female caribou and population projections.

13.3.2 Screening for Cumulative Environmental Effects

Residual effects from the Kiggavik Project and effects from other projects in the area were assessed to determine the overall cumulative effects on caribou and muskox in the region. Residual effects from the Project on caribou and muskox include:

- Increased mortality risk
- Habitat loss and reduced habitat effectiveness
- Changes to movement
- Possible energetic costs and changes in population projections

Residual effects of increased mortality risk and habitat loss/reduced effectiveness are expected because an all-season road can provide additional hunter access over several generations of caribou and muskox, 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 specifically in this section.

Although it is difficult to determine the Project’s effect on movement, there is likely to be a residual effect that cannot be mitigated due to long-term or permanent features left on the landscape. Project features including the Winter Road or the All-Season Road may act cumulatively with existing road corridors, particularly the Meadowbank Mine access road to Baker Lake, to limit caribou movement. Future projects may require linear features (roads, pipelines, or transmission lines) that could also act cumulatively with the linear disturbances from the Project to affect caribou movement. Animal movement is not addressed specifically in the cumulative effects assessment. An evaluation of caribou energetics and population projections encompasses the possible energetic costs of changes to movement patterns and habitat use. The assessment of caribou energetics is summarized below. Data do not exist and an assessment at that scale is not conducted for muskox.

Similar to effects on movement, cumulative effects to health are difficult to quantify. However, there are existing and likely future mining operations within the ranges of caribou and muskox interacting with the Project. Those projects possibly have residual effects on animal health. Animal health is not addressed specifically in the cumulative effects assessment. An evaluation of caribou energetics, described below, indirectly quantifies potential cumulative effects on caribou health. Similar to the assessment of movement, data do not exist for muskox at the scale necessary for energetics modelling, and a cumulative effects assessment for muskox is not conducted.

For past, present or likely future projects/activities to be included in the cumulative effects assessment, three conditions were required to warrant further assessment:

1. Adequate qualitative and/or quantitative information on a project or activity is publicly available to allow for spatial and temporal characterization;
2. The project spatially overlaps with the residual effects of the Kiggavik Project; and
3. The project temporally overlaps with the residual effects of the Kiggavik Project.

The resulting Project Inclusion List (PIL; described further in Tier 1, Appendix 1E) was determined by cross-referencing projects developed from a number of sources, and includes projects or activities in Nunavut, Northwest Territories, northern Alberta, Saskatchewan and Manitoba.

13.3.3 Assessment of Cumulative Effects: Change in Caribou Mortality

Although the Kiggavik Project will not have a measurable or reasonably-expected adverse effect on mortality risk, there are many causes of caribou mortality that could act cumulatively to effect mortality. The predominant cause of cumulate mortality related to potential Project effects is the potential for increased cumulative harvest mortality because access to the mine will provide increased harvester access that may result in harvest beyond sustainable levels if not managed by the responsible stakeholders.

The cumulative effects assessment of mortality focuses on the Qamanirjuaq herd because their annual range extends throughout Nunavut, NWT, Manitoba, and Saskatchewan, has the greatest amount of current and future anthropogenic activity within their range, and the herd is harvested by a number of communities throughout their range. The potential for increased harvest as a result of increased harvester access (on the All-Season Road) and improved knowledge of caribou locations could act cumulatively with other harvest pressures on the Qamanirjuaq caribou herd. An analyses of harvest on the other herds (e.g., Ahiak) is not provided as there are no harvest estimates for those herds that may interact with the Project.

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, the determination of whether Baker Lake harvesters are capable of harvesting more caribou than sustainable limits is difficult to determine, creating uncertainty in the confidence of cumulative effects predictions.

13.3.3.1 Effect Mechanisms and Linkages for Change in Caribou Mortality

Caribou mortality may increase indirectly through increased harvesting access into hunting areas or greater knowledge about caribou in the area. The effects of roads are seen as a proximate cause to many wildlife management challenges as there appears to be a correlation between road access and the level of effort required for management of caribou herds. Management strategies to reduce this effect have required strict harvest management actions and annual caribou monitoring surveys to adjust harvest quotas and ensure sustainable populations.

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 Nunavut Wildlife Management Board (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 Department of Environment 2007).

Increased hunter harvest of caribou can cumulatively increase due to the indirect effect of providing increased hunter access to and knowledge of the land base. 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 (Priest and Usher 2004; Baker Lake HHS). The low harvest pressure in this 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 All-Season Road would increase access to this area, which would likely result in an increased harvest of animals from this area.

Baker Lake hunters are known to use roads for hunting caribou. Although some hunters may 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 was 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[198]:

- *“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.”*

The 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 Department of Environment 2005). Further, the GN does not feel it necessary, for conservation purposes, to regulate harvesting of caribou through a restriction on harvest season.

[198] 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’.

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.

The Project will increase mortality risk primarily to the Qamanirjuaq caribou when they are present in the RAA during post-calving and summer dispersal. 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). Based on recent collar information, the 40% apportioned to Wager Bay herd is likely a combination of Wager Bay and Lorillard caribou. Mortality risk during winter is not expected to increase because hunters access their traditional hunting areas via 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 have been collected infrequently and inconsistently since the early 1970s. However, the harvest may increase to meet the demands of an increasing 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 assessment of 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 may 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 All-Season Road, but the road may facilitate an increase in harvest of Qamanirjuaq caribou.
- Total foreseeable mortality risk (per year) from all sources 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 that is unlikely to have a cumulative effect; or b) increase total harvest that will have a cumulative effect across the caribou populations.
- Other Project contributions to harvest include indirect effects of the Meadowbank Project's access road that may facilitate access to Lorillard, Wager Bay, and 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 operational 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.

13.3.3.2 Analytical Methods for Change in Caribou Mortality

The effects of cumulative harvest-related mortality were analyzed by reviewing harvest patterns and caribou population trends near the community of Baker Lake. Increased mortality risk was quantified by determining the caribou herds that would most likely be exposed to Project activities (direct effect) and hunter harvest (indirect effect) west of the Thelon River during the snow-free season (when Project facilities could facilitate harvester access).

The following information is used for determining the increased mortality risk to caribou and level of significance included:

- 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 focused 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 were reviewed. Hunter harvest data (traditional, recreational, and commercial recreational) was 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 was then compared to identified harvest thresholds.

The following assumptions were made to assist the prediction of 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 (Baker Lake HHS; Tier 3, Appendix 6C) caribou.
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 we assume that 3% of the herd was present in that area.
7. Beverly, Ahiak, Lorillard, Qamanirjuaq and Wager Bay 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 given high point of ground); beyond 10 km the risk is indistinguishable from baseline conditions.

The All-Season Road was 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 option is anticipated to provide little improvement to winter harvest access.

13.3.3.3 Baseline Conditions for Change in Caribou Mortality

To determine the Project's potential for increased risk of caribou mortality, an understanding of the following was 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.

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.

Currently, most of the harvest pressure during the ice-free period likely comes from harvesters travelling on the Thelon River or travelling north from Baker Lake. The proposed All-Season Road is unlikely to increase harvest related mortality risk to Wager Bay caribou because these caribou occur within RAA during the snow-free season (5/16 collared animals spent time in the RAA during the winter season). Lorillard and Ahiak caribou also occur within the RAA mostly during the winter period (14/28 Lorillard and 16/30 Ahiak collared animals), and their occurrence has primarily been north and west of the proposed mine site (Tier 3, Appendix 6C, Figures 5.7-3B and 3D). Qamanirjuaq caribou occur within the RAA primarily during post-calving (17/93 collared animals) and summer dispersal (6/93 collared animals), with most collar locations occurring south of the proposed All-Season Road.

Two, four, and one collared caribou from the Ahiak, Qamanirjuaq, and Lorillard herds, respectively, have been recorded within the All-Season Road LAA during the snow-free season. Assuming that collars are representative of the herd, these numbers correspond to 6.7% of the Ahiak, 4.3% of the Qamanirjuaq, and 3.5% of the Lorillard collared caribou during 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.

Harvest Distribution and Trends

Overview — Caribou hunting areas were identified throughout the Kiggavik RAA from IQ and engagement data, hunter data, and previous land use studies (e.g., IDS 1978; NLUIS 1980). IQ data note that *areas used for hunting, trapping, and other resources are dependent on the movements of the caribou. A comparison between areas used by residents of Baker Lake in the past, and areas currently used is difficult as variation in caribou migration routes have occurred over the years* (IQ-BL01 2009; IQ-BL02 2008). 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 was 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), and 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). *Pitz Lake and Princess Mary Lake are both well used. Both have winter and summer camping areas, migratory areas, fish spawning, gravesites, caribou crossings, and spiritual significant areas* (EN-BL HTO Feb 2013; Tier 3, Appendix 6C, Figure 5.1-12). *In December, we hunt south of Baker when the Qamanirjuaq herd moves through* (IQ-BLHT 2011).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 Tier 3, Appendix 6D, Figures 5.1-12 and 13).

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 (Priest and Usher 2004). 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. What is unclear is 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, most of the caribou harvested around the Kiggavik RAA are likely from the Ahiak, Lorillard, and Qamanirjuaq herds. For the larger Kivalliq region, animals from Wager Bay, and some from the Beverly herd, are also hunted. Hunters from Baker Lake are the only Nunavut-based hunters to harvest from the Beverly herd, but this herd is hunted primarily by the Dene of northern Saskatchewan, western NWT, and northern Manitoba (NPC 2000). August, September, and October are traditionally the months of highest total caribou harvest in Baker Lake based on the NWMB Harvest Study (Priest and Usher 2004) 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. From the 1970s to present day, total caribou harvest/year in Baker Lake has increased from about 4,000 in the mid-1970s to current estimates by the Beverly and Qamanirjuaq Caribou Management Board (BQCMB) of up to about 9,000/year. Some of this increase may be associated with an estimated 2-3% Baker Lake population growth (Tier 2, Volume 9, Section 5.3.2). This increase is reiterated in IQ and engagement data: *there are more caribou being taken and the town is growing, and there are many community feasts. There are feasts with caribou all the time* (EN-BL OH Oct 2012).

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). Total estimated annual caribou harvest for Baker Lake households from the AEM/AREVA HHS from 2007 to 2013 ranges from 3,000 to 6,000 caribou (see Tier 3, Volume 6, 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 2008). Using the combined harvest range of 2,000 (BQCMB 2008) to 6,000 animals (Baker Lake HHS), Baker Lake hunters may be annually harvesting 800 to 2,400 Qamanirjuaq caribou (Table 13.3-1). Based on the BQCMB's (2008) total annual Qamanirjuaq caribou harvest of 9,070 animals, Baker Lake hunters are responsible for a minimum of 8.8% (800 of 9,070 harvested) and maximum of 26% (2,400 of 9.070 harvested) of the total Qamanirjuaq caribou harvest (800/9,070).

Table 13.3-1 Baker Lake Community Harvest Estimates by Caribou Herds

Herd	Proportion harvested by Baker Lake Hunters[1] (%)	BQCMB harvest estimate of Qamanirjuaq[2]	AEM/AREVA Harvest Estimate[3]
Beverly and Ahiak	20	400	1,200
Qamanirjuaq	40	800	2,400
Other (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 2008) [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 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 on the range is adjusted by a factor of 1.25 to account for estimated wounding loss (Campbell et al. 2010). 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 this herd is approximately 13,075 caribou.

Assuming equal harvest pressure throughout the region, and a reasonable 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 minus 800) Qamanirjuaq caribou using the BQCMB (2008) harvest estimate (using the lower harvest estimate, Table 13.3-1) and current population estimate.
b. The community is already harvesting at a level that is cumulatively exceeding sustainable limits by 1,249 (1,151 minus 2,400) using the higher harvest estimate Table 13.3-1; Baker Lake HHS) and current caribou population estimate.

13.3.3.4 Mitigation Measures for Cumulative Change in Caribou 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.

Mitigation by AREVA

AREVA will implement a number of mitigation measures to minimize the Project-related mortality risk to caribou populations interacting with the Project. Specific Project design measures include:

- 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.
- Roads will be designated for seasonal use (for the winter access road only).

Mitigation measures to be implemented during the active Project phases include:

- closure in accordance with the caribou decision matrix
- 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

- wildlife monitors will provide hazard warnings to drivers and implement road travel restrictions when high numbers of caribou (e.g., 100s) are observed within 300 m of a road
- employee awareness training
- develop a wildlife mortality reporting protocol
- monitoring and documentation of road and air traffic volumes as a correlate 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

The implementation of those mitigation measures to reduce the direct effects on caribou mortality risk will be effective for eliminating Project-related direct effects on the herds that interact with the Project's RAA. More detail on mitigation and monitoring for caribou is available in the WMMP (Tier 3, Volume 6, Appendix 6D).

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 that want to use the Winter Road will follow the same mitigation measures adopted by Kiggavik; 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 hunting restriction that may be issued under the authority of the NLCA. Collaboration with responsible Inuit and local organizations for monitoring and management programs related to the Kiggavik access road that are deemed appropriate by all parties.
- use of wildlife monitors to document all hunter-associated caribou mortalities (e.g., number, location)

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 including the following:

- **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 and NWMB to manage hunting (locations, herds, number of kills)
- monitoring and documentation of caribou kills by community

13.3.3.5 Residual Cumulative Change in Caribou 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 and knowledge for traditional and recreational hunters.

The All-Season Road could provide improved access to the area west of the Thelon river for up to an additional eight months of the year when the land may be snow-free and the river not frozen. Increased harvester access could be improved when the road is operating during the snow-free season (beginning in spring, lasting until fall). The Winter Road option 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 Road will overlap with spring migration in March, when access via snowmobiles is still possible. The proposed All-Season Road may have increased potential to affect caribou mortality as it will provide hunter access to an area that has been relatively inaccessible during the snow-free season. The Winter Road option will have less of an effect because hunters are able to access the same area by snowmobile during the winter.

The cumulative effects of the All-Season Road option would provide hunter access to the area west of the Thelon River, a region with historically and currently low hunting pressure in the ice-free period. Assuming equal harvest pressure throughout the region, the current Qamanirjuaq herd harvest estimates for Baker Lake indicate that:

- The harvest of an additional 351 Qamanirjuaq caribou using the BQCMB (2008) harvest estimate (using the lower harvest estimate; Table 13.3-1) and current caribou population estimate or
- The harvest is at a rate that is exceeding the population sustainable limits by 1,249 caribou using the higher harvest estimate (Table 13.3-1; Baker Lake HHS) and current caribou population estimate

Mine and All-Season Road

The All-Season Road option will increase the mortality risk to the Qamanirjuaq caribou during the snow-free season by facilitating hunter access and improving harvester knowledge of caribou locations. 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 All-Season Road because few collared caribou have been recorded occurring in the All-Season Road ZOI; however, year-to-year variation suggests there may be some years where many Qamanirjuaq caribou are present in greater numbers. Most of the Baker Lake resident harvest of Qamanirjuaq caribou is occurring elsewhere in the Kivalliq region (i.e., likely south of Baker Lake).

Qamanirjuaq caribou herd collar location data was collected from 1993 to 2012, and is assumed to be representative of the Qamanirjuaq herd movement and distribution during the past two decades (see Section 13.1.4 for technical limitations of collar data). Collared Qamanirjuaq caribou appear to encounter and spend the most time in the ZOI during the post-calving and summer seasons, especially since 2005. Although no collar locations were recorded in the ZOI from 1993 to 2004, this does not necessarily suggest there was a change in distribution, rather, the number of collars in the herd increased from about 2004 onwards, likely capturing more of the variability in herd distribution.

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 current harvest rates and population size. Regardless of the current harvest, the effect of 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 All-Season Road will increase harvest pressure on other herds in the area when the road is operating (primarily the Ahiak and Lorillard herds), but it is difficult to determine if or how this harvest will affect these herds because current population estimates are either not available or are outdated. The Wager Bay herd is unlikely to be affected by the 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 1999 to 2013 (excluding 2007–2008 when no collars were active) and is probably representative of the herd's distribution. Current evidence suggests that Beverly caribou do not interact with the RAA, and thus encounters with the road (and harvesters) is very unlikely.

Mine and Winter Road

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.

The Winter Road option will not increase the mortality risk to the Qamanirjuaq caribou during the months the road is operational (December to March) because the area is already accessible to harvesters via snowmobiles. From December to March, there could be some Qamanirjuaq caribou in the area around the Winter Road; however, there has only been one Qamanirjuaq collar in the area at that time since 1993. The Kiggavik Project is clearly not within the migratory path to any of the herd's calving grounds.

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 Winter 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 Winter Road will not increase harvest pressure on other herds in the area when the road is operating (primarily the Ahiak and Lorillard herds). The Wager Bay herd is very unlikely to be affected by the Winter 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. Current evidence suggests that Beverly caribou do not interact with the RAA, and thus encounters with the road (and harvesters) is very unlikely.

13.3.3.6 Determination of Significance for Cumulative Change in Caribou 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.

The mine and Winter Road option 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 and harvesters already have access to the area via snowmobile. The 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 in the post-calving and summer seasons when their residency time in the area is the greatest. 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.

Regardless of the current harvest, the effect of the All-Season Road on hunter access and, consequently, caribou mortality is expected to be undetectable at the herd level. No caribou herd is likely to be affected by increased harvest pressure due to any of the access road alternatives (including the All-Season option). Therefore, a restriction on harvesting as required or suggested mitigation is not presented but rather it is noted that a mechanism is in place under the Nunavut Land Claims Agreement for the management of harvest. Harvest management responsibilities include the following organizations GN, NWMB, the RWO, and HTO as outlined in Article 5 of the NLCA. 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 Project.

13.3.3.7 Compliance and Environmental Monitoring for Cumulative Change in Caribou Mortality

Compliance and environmental monitoring for cumulative 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 delineation and population estimate survey (determine regional herd population trends)
- continue Project-specific caribou monitoring programs (e.g., ground-based observations)

13.3.4 Assessment of the Cumulative Effects: Change in Habitat Availability

The Project in isolation will have a not significant adverse effect on caribou habitat within the Qamanirjuaq caribou herd growing season range or the Ahiak caribou herd winter range. The Project is expected to have a not significant loss of muskox habitat within 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. The cumulative effect of the habitat loss across the range has the potential to reduce the overall availability of habitat for wildlife in the region to a point that population level effects could occur.

13.3.4.1 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 reduced habitat effectiveness in the region. While human disturbance causes a loss of suitable 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 range of the caribou herds that could reduce the availability of habitat include:

- **Operating mines** — The footprint of mines and mine access roads reduces the availability of habitat for wildlife. There are several operating mines in the cumulative effects assessment area There also several mines planned in the near future (Tier 1, Technical Appendix 1E).
- **Mineral Exploration** — There are numerous mineral deposits being explored in the region. Each of these operations has some amount of human activity (e.g., drilling, surveying, helicopter flights). Exploration activities mostly take place during the summer and the footprint of the camps, drill pads, and other disturbances is relatively small.
- **Municipalities** — Among other, 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.
- **Roads** — The footprint of all-season and winter roads with the CEAA reduces habitat availability for caribou and muskox.

The Kiggavik Project will add to the overall habitat loss within the seasonal ranges of the caribou herds that interact with the Project.

The Meliadine project assessed cumulative habitat loss in an assessment area that included most of the mainland portion of the Kivalliq region south of Baker Lake. Their assessment included consideration of disturbance footprints and ZOIs from numerous projects in that area. That area included the Kiggavik Project, and the majority of the growing season habitat of the Qamanirjuaq caribou. They concluded that direct incremental and cumulative changes in area from known and expected future developments and their ZOIs were expected to be less than 3.0% (Golder Associates Ltd. 2014, Sec. 6.6.4.2.2).

13.3.4.2 Analytical Methods for Cumulative Change in Habitat Availability

The option with the largest potential effect on terrestrial wildlife habitat, the mine and All-Season Road with the maximum Project footprint was used to assess the cumulative effects of the Project on habitat availability. The cumulative effects assessment area includes the combined ranges of Beverly and Qamanirjuaq caribou herds, as requested by the BQCMB, and the Lorillard, Ahiak and Wager Bay herds. All known projects within the cumulative effects assessment were included in the PIL. The footprint of those projects were included in the PIL and used to calculate the total habitat loss within the cumulative effects assessment area with and without the Project. Community footprints listed in the PIL are the municipal boundaries and are large overestimates of the actual community footprints. Communities footprints used to estimate the cumulative infrastructure footprints within the cumulative effects assessment area were estimated by manually generating ellipses around the concentrated community infrastructure (using Google Earth imagery) and clipping those areas so waterbodies (e.g., lakes and river) were removed from the estimate. The estimate is a more accurate reflection of the community disturbance footprint.

To assess the potential cumulative change in habitat availability to caribou, projects or activities listed in the PIL were considered in the assessment. In an effort to better quantify cumulative direct habitat loss, spatial footprints for each project or activity in the PIL were determined or estimated where possible (Appendix 1E).

Since habitat quality information was not available for the entire cumulative caribou effects study area, the habitat assessment was limited to a calculation of the total area removed by development.

13.3.4.3 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 (Section 13.2.2.4).

13.3.4.4 Residual Cumulative Change in Habitat Availability

Caribou

The footprints from permanent communities and closed mines are the largest contributing factor to direct habitat loss in the cumulative effect assessment area; each accounts for approximately 0.01% of habitat loss and together they represent about 55% of the footprint disturbance in the area. Overall footprint loss, including Future Case additions, accounts for 0.43% of the area. Either of the Kiggavik options adds an additional 0.001% of habitat loss to the area (Table 13.3-2). The influence of the potential zones of influence from these disturbance activities are assessed as a potential effect on caribou energetics (Section 13.3.5).

Table 13.3-2 Sum of activity footprints in the terrestrial cumulative effects area

Case	Land use	Sum of footprint (km^2)	% of terrestrial CEAA[1]
Base Case	Community	144	0.010%
	Transportation[2]	44	0.003%
	Mining — operating mine	76	0.005%
	Mining — past/inactive	154	0.010%
	Mining — exploration	5	0.000%
Future Case additions	Mining — proposed mine	104	0.007%
	Transportation	12.1	0.001%
Total		6,525	0.036%
	Kiggavik Project ASR option	**17.8**	**0.001%**
	Kiggavik Project WR option	15.8	0.001%
NOTES: Total area of terrestrial CEAA = 1,501,608 km^2 Assumed 10 m width on transportation corridors (provided as length in PIL)			

Muskox

The total 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.

13.3.4.5 Determination of Significance for Cumulative Change in Habitat Availability

Residual effects include the accumulated loss of seasonal habitat for caribou, both as a result of the Kiggavik Project and from other past, present, and future projects in the region. Currently, there are few human activities in the region that affect wildlife. The footprint of the communities alone are by far the greatest source of habitat loss for wildlife. The addition of the Kiggavik Project to these disturbances is not expected to measurably reduce the amount of caribou 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.

There will be a cumulative loss of habitat in areas that cannot be reclaimed entirely to baseline conditions. However, given the scale of the range of muskox and caribou, cumulative loss can be mitigated by the collective actions of individual Project proponents, which could include minimizing/mitigating disturbances to wildlife and reclaiming habitats if they are disturbed. Anthropogenic disturbances can act cumulatively with natural disturbances such as fire on caribou winter range, but the scale at which fires occur would mask any effect of industrial-related habitat losses. Considering mitigation and the low likelihood of large-scale anthropogenic disturbances in this landscape, the cumulative effect on habitat loss is expected to be not significant.

13.3.4.6 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 (Section **Error! Reference source not found.**).

13.3.5 Assessment of the Cumulative Effects: Change in Caribou Energetics

An assessment of the Project and cumulative effects on caribou energetics and population projections was conducted. The section below summarizes the methods and results of those analyses presented in Attachment A — *Kiggavik Project Effects: Energy-Protein and Population Modeling of the Qamanirjuaq Caribou Herd*. This approach follows a similar method used in the assessment of the Mary River Project on Baffin Island (Russell 2012, 2014) and is supported in the peer-reviewed literature (Russell et al. 2005, White et al in press).

For this analysis, potential effects on the Qamanirjuaq herd, a herd that is relatively well-documented, has the most development within its range and is relevant to the mandate of the BQCMB (who, among others, have raised cumulative effects concerns), was modeled. Although a similar assessment approach could be attempted on all of the herds, the remaining herds are poorly understood and have less development within their ranges. We maintain however that the results from modeling the Qamanirjuaq herd provide a relative framework within which to consider implications to the other herds, as the potential effects on the Qamanirjuaq herd likely represent a "worst case" scenario.

To predict potential Project and cumulative effects on caribou energetics and populations, an individual-based energy-protein (E-P) model linked to a population model was used. Those tools were used to provide an analysis of the expected range of fall body weights of cows and calves incorporating the variability observed in the individual caribou encounters with infrastructure zones of influence (ZOI) within the Qamanirjuaq caribou range. The analyses of caribou encounter rates with possible disturbances is based on possible caribou movement and encounters with a variety of disturbances evaluated using satellite collar telemetry data.

The analyses of caribou encounter rates with possible disturbances is based on possible caribou movement and encounters with a variety of disturbances evaluated using satellite collar telemetry data. The disturbances included mineral exploration, mines, energy corridors, all season roads, winter roads, and towns/municipalities. The hypothetical ZOIs were based primarily on what have been used in a number of caribou effects assessments for northern projects and from those published in the literature. The ZOIs include a 14 km radius around mine sites, 15 kilometres around municipalities, five kilometres around exploration sites, and other sizes proportional to the hypothetical disturbances. The ZOIs err on the side of precaution in overestimating the likely areas of disturbance for reasons discussed in Tier 2, Volume 6, Attachment A. The resulting total areas of the ZOI are summarized by the Qamanirjuaq seasonal ranges (Table 13.3-3). The post-calving portion of the range experiences the greatest disturbance (6.0%), followed by spring migration and calving (2.7% each). By far, the greatest contributor by area covered by a ZOI is the municipalities in the post-calving range (accounting for 5.8% of the total 6% coverage).

Table 13.3-3 Disturbance Areas within the Zone of Influence (ZOI) of Features in the Seasonal Ranges of the Qamanirjuaq Caribou Herd

Seasonal Range[1]	ZOI km²(% of range)		% of range covered by land use ZOI					
	Base Case[2]	Project Case[2]	Municipality	All-Season Road	Winter Road	Mineral Exploration	Mine	Energy Corridor
Spring migration	1,907 (2.7%)	1,907 (2.7%)	2.4	0.5	0.1	0.1	0.0	0.1
Calving	798 (2.7%)	798 (2.7%)	2.4	0.0	0.0	0.2	0.0	0.0
Post-calving	5,107 (6.0%)	5,190 (6.1%)	5.3	0.4	0.0	0.8	0.0	0.0
Summer dispersal	2,573 (2.4%)	2,581 (2.4%)	1.7	0.0	0.0	0.7	0.0	0.0
Fall and Rut	1,384 (0.9%)	1,386 (0.9%)	0.2	0.1	0.0	0.5	0.0	0.1
Early and Late winter	2,263 (1.7%)	2,263 (1.7%)	0.7	0.7	0.1	0.3	0.0	0.2

Notes:

[1]Seasonal ranges were generated using a kernel density analysis on caribou telemetry locations - density was constrained to the 95% utilization distribution.

[2]Total disturbance cases do not include duplication of overlapping disturbance ZOIs (i.e., the sum of the land use proportions add up to more than the corresponding cumulative ZOI proportion).

The key output indicators from the E-P model were the fall body weight of lactating cows and their calves. Those values provided inputs with respect to probability of pregnancy and over-winter calf mortality at the population scale. In "populating" both the energy-protein (E-P) model and the population model, the most appropriate and available data were used. For the E-P model, existing datasets on vegetation communities within the Qamanirjuaq's herd range were augmented with generic data from the CircumArctic Rangifer Monitoring and Assessment (CARMA) network to quantify forage quality/quantity and seasonal diet. Active/rest cycles were driven by known relationships between the proportions of day spent resting as dictated by latitude and day length, while the partition of the active cycle was primarily driven by climatic conditions developed for the Qamanirjuaq herd by CARMA. Collections of just under 1,000 caribou in the 1960s provided information of body weights, age and sex structure, pregnancy rates and mortality.A number of development scenarios were used to accomplish six objectives:

1. Determine the individual and population level effects of the Kiggavik Project on the Qamanirjuaq herd.
2. Determine potential effects from other active and potential projects on the Qamanirjuaq herd.
3. Determine the added incremental impact of the Kiggavik project with respect to the total impact from development within the range of the Qamanirjuaq herd.
4. Predict variability of fall body condition of cows and calves within the herd by modeling a cross section of individual encounter rates.
5. Determine if the season of encounters with development effects fall body weights.
6. Determine harvest adjustments needed to offset development effects.

The primary dataset that used to quantify encounter rates that individuals of the Qamanirjuaq herd had with infrastructure ZOI was radio-collar data from 1993–2012. GIS analysis was used to determine the residency time that each collared caribou spent within ZOIs both for existing projects, likely projects and, separately, for a future Kiggavik mine. The scenarios were:

1. BASE scenario — no development, no encounters.
2. ASR — caribou were modeled based on a liberal assessment of encounter rates and residency time in the mine and All-Season Road (ASR) ZOI.
3. WR — caribou were modeled based on a liberal assessment of encounter rates and residency time in the mine and Winter Road (WR) ZOI.
4. CE — Cumulative Effects (CE) were modeled using the effects of disturbance on caribou encountering ZOIs within their range based on average seasonal residency for collars from 2005 to 2012.
5. CE+ASR — the incremental residency times in the ASR were added to the CE scenario to determine the total and incremental effects with the Kiggavik project.

Although not scenarios per se, the maximum residency time individual collars experienced in each season was determined, and modeled the quartile times (divided the dataset into quarters to provide an estimate of the variation in fall body weight of cows and calves that might be expected from the spectrum of total and seasonal exposures. As well, the importance of season (i.e. when they encounter a ZOI) in predicting disturbance effects was explored.

Results of running the scenarios through the E-P model were used as input for the population model through probability of pregnancy (fall body weight of cows) and over-winter survival of calves (fall body weight of calves). The Qamanirjuaq population was modeled over 26 years (2014–2040) and used the population size as the indicator of population effects. Further, the change in harvest (through lower annual harvest or through lower proportion of females in the harvest) possibly needed to offset the population effects of development was determined.

In 1,274 “opportunities,” collared caribou only encountered the ASR 18 times and the WR 18 times for an encounter rate of 1.4%. Most of the encounters, as expected, were in the post-calving period (67% ASR and 72% WR). The major difference between the ASR and the WR was that the average residency time in the WR post-calving period was much lower (0.4 days) compared to the ASR (1.6 days). As well no encounters occurred in the late winter period in the WR compared to 1 encounter in the ASR.

The exposure to the ASR was modeled using average seasonal residency times recorded, and assumed all seasonal encounters occurred in the same year (total of 12 days resident in the ASR ZOI) and were experienced by the same individual — although encounters from collar data were interspersed from 2005–2012 and involved 12 different collars. In fact only 1 collar (that wintered near Kiggavik) spent 8 days associated with the ZOI, 2 collars spent 6 days and the remaining collars spent less than a day.

Compared to the base run, the modeled cows averaged 0.6 kg lower fall body weight and calves 0.46 kg lower body weight. Assuming a 1.4% encounter rate with the Kiggavik Project, there was no difference (overlapping Standard Errors) in the final population size between the ASR scenario and the base scenario, even while keeping variability around the vital rate estimates extremely low. Given the lower residency days (compared to ASR) in the WR and the fact that 90% of the WR encounters were in post-calving and summer (when that road option is inactive), we didn’t see the need to model the WR scenario given the more severe scenario (ASR) did not result in a population effect.

Results from the CE scenarios projected an average fall body weight decline of 0.8 kg and 0.62 kg for cows and calves, respectively. The CE+ASR predicted a decline of 0.8 kg and 0.68 kg decline for cows and calves respectively. Population size in 2040, based on E-P model output from these scenarios, and weighting by the percent of collars that interacted with the CE development projects (30% average across seasons), was projected an average 24,000 caribou decline from baseline population estimates. Again there was no significant difference between the CE and the CE+ASR estimates. For the CE scenario, the change in harvesting to offset the 24,000 decline (equivalent to 5.8% reduction in herd size compared to baseline) was either a 5.1% reduced harvest or drop in the proportion of females in the harvest from 65% to 62%. Even though there was not a significant difference between the CE and the CE+ASR scenario population estimate, multiple runs of the stochastic model resulted in a slightly lower, through still not significant, average population size. Based on the average comparison from CE to CE+ASR, the harvest adjustment for CE+ASR compared to the CE estimate was 8 less caribou harvested per year or a drop in the proportion of cows from 62 % to 61.5 %. It is important to emphasize that the 24,000 drop in final population size was based on a very pessimistic (i.e., errs on the side of extreme precaution) disturbance scenario for caribou encountering ZOIs, especially with respect to the disturbance through the ZOI and the reduction in foraging time and eating intensity used in this analysis.

For individual collars, that maximum residency time in any year was tallied, resulting in a maximum annual residency time of 53 days. Dividing the individual collar results into quartiles, the fall body weights based on average time in each season for the 4 quartiles was modelled. Results indicated a steady decline in fall body weight for adult lactating cows from baseline conditions to high interactions (Q4: 100%). Body weight of adult cows ranged from a baseline of 78.9 kg to 76.3 kg for the worst case (the Q4: 100%) and calves from 53.41 to 52.68 kg. Interestingly the lowest calf weights were noted for the Q3: 75% scenario (52.62 kg).

The final analysis was to help determine the importance of season of ZOI exposure to fall body weight of cows and calves. This assumed that there would be on average 13 days of residency and that all the days would be in one of the seven seasons. Fall body weight of cows ranged from 78.9 to 77.3 kg and calves from 53.6 to 51.4 kg. The ecological reasons for the seasonal variability is discussed.

From our analysis we determined that the population level effects of the Kiggavik project will be not different from populations in the absence of the Kiggavik project. Any residual effects would be substantially masked by natural variability. While we were able to model ASR effects, based on current collared caribou movements, the WR option does not disturb the caribou to a scale that we could even develop an E-P model scenario.

13.3.6 Summary of Project and Cumulative Environmental Effects on Caribou and Muskox

Within the wildlife cumulative effects assessment area, the Kiggavik Project contributes an additional 0.001% habitat loss. AREVA acknowledges that the Project may provide additional harvester access, and there may be an increase in the cumulative harvest of caribou. The Project likely does not contribute in a measurable way to any change in caribou energetics or result in a change to population growth possibilities. Table 13.3-4 summarizes the cumulative effects of the Project on caribou.

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	Wildlife Management authorities' responsibility
	Project Contribution to Cumulative Effect	Unintended harvester access	Private road, road closure, access management	N	N	N	MT	R	R	U	N	M	N/A	AREVA enforcement of company policies, follow-up on any project-related mortalities, take corrective actions.
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	AREVA contribution to collaring program and habitat studies
	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
Changes in caribou energetics and population projections	Cumulative Effect with Project (Future Case)	Summarized in the PIL.												AREVA advocates regional-level cumulative effects monitoring as a component of the Nunavut General Monitoring Programme.
	Project Contribution to Cumulative Effect	NA	NA	N	L	N	LT	C	R	U	N	M	N/A	

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 LAA.
M Moderate: Observable effect on wildlife species but not likely to affect the species' sustainability in the RAA.
H High: Measurable effect on wildlife species that will likely affect the species' sustainability in the RAA.

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.

As with the Project effects, AREVA acknowledges some level of uncertainty in the cumulative effects predictions. The basis of the uncertainty remains the same and reflects regional-level data deficiencies and uncertainties beyond the capabilities of AREVA or any one party to address. The uncertainties include potentially non-specific habitat classification that could mislead conclusions about land productivity, a lack of studies showing a clear response of caribou behaviour to disturbances, modelling bias, and unknown influence of a mining project on improving access and harvester success.

13.4 Transboundary Effects Assessment for Caribou and Muskox

The assessment of cumulative effects on caribou for mortality risk and habitat availability were assessed within seasonal ranges that extended well beyond the boundaries of Nunavut into northern Manitoba and Saskatchewan and the Northwest Territories. Predicted project effects on caribou include direct mortality (collisions), direct and indirect habitat loss (Project footprint, dust and sensory disturbance), and possible avoidance of the Project area but no alteration to migration patterns and no change to health. Predicted cumulative effects to caribou include a possible shift in proportional caribou herd take or an overall increase in harvest to the Qamanirjuaq herd given the development of the alternative All-Season access road option and potential associated changes in harvest patterns.

The latter effect, in combination with harvesting of the same caribou populations outside of Nunavut, would be a transboundary effect. Given the analytical methods used to assess cumulative were conducted in a study area that was transboundary, that effects assessment incorporates transboundary effects. Considering that none of the Project effects or the cumulative effects to caribou are significant, no significant adverse transboundary effects are predicted for caribou. As noted in the Tier 2, Volume 6, Section 13.3.3.4, AREVA will implement a number of measures to manage mortality risk associated with the Project (i.e., vehicle-wildlife collisions). In addition, AREVA will collaborate with other industry proponents, government agencies and Inuit organizations to support monitoring of caribou herds, document mortality, and promote initiatives by Inuit organizations to ensure the long-term viability of the traditional, resident and sport harvest.

13.5 Summary of Residual Effects on Caribou and Muskox

13.5.1 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. IQ, baseline data, and collar data from the local and regional herds shows that few caribou are expected to interact with the Project. Caribou from the Qamanirjuaq and Ahiak 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 major 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 from exposure the COPCs.

13.5.2 Cumulative Effects

AREVA recognizes the concerns regarding the potential cumulative effect on caribou and muskox from the Kiggavik Project. The cumulative effects analysis shows that project footprints contribute to a marginal loss of habitat. There are a limited number of projects that appear to be at any reasonable stage of development to be considered as potential future projects. The likelihood of these projects occurring consecutively and year-round with the Kiggavik Project is unknown and consecutive operation is unlikely. It is expected that if induced projects go ahead, they will adopt measures to minimize or eliminate effects to caribou.

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. The increased mortality risk is the result of potential hunter/harvester access, 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 likely not significant. Multi-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).

13.5.3 Effects of Climate Change on Project and Cumulative Effects 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). Technical Appendix 5K explored 23 climate change ensembles, which reflect different combinations of models and emission scenarios. Most models predict an increase in temperature throughout the year however the magnitude of warming in the winter is highest. The models output an average predicted change in temperature of 4.7 °C for the years 2071–2099, from modeled baseline conditions. This warming is highest during winter, with December temperatures predicted to warm by an average of 8.4 °C. This is consistent with IQ available from the Nunavut Climate Change Centre and the Arctic Climate Impact Assessment Report (ACIAR, 2005). 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, ACIAR, 2005). 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 the consequences of environmental stochasticity, especially 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 III, 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 too low to adequately inform an effects assessment. 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.

13.6 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 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
- traffic management, including possible 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 mine site 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

13.7 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.

13.8 Overall Project and Cumulative Effects on Caribou and Muskox

The Project footprint causes long-term loss of habitat. During construction and operation there will be a zone of influence that will make some habitat less effective within a certain distance of the Project. There is an increase in mortality risk to caribou if harvester access is increased. The Project effect on caribou energetics is likely low and will not have an effect on future population projections. The pre-existing cumulative effect of harvest and disturbance effects on caribou was characterized in terms of caribou energetics and population modeling. There are no known cumulative effects on muskox because the Kiggavik Project is the only known project in MX/21.

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 All-Season Road could interact cumulatively with other climate-driven pressures on the Qamanirjuaq caribou herd, which could influence mortality rate.

Potential localized impacts on Inuit harvesting is addressed in FEIS Tier 2 Volume 9 Part1 Socio-Economic Environment and depends in part on the results of this terrestrial assessment. The terrestrial assessment concluded there would be no significant Project or cumulative impacts on terrestrial animals. It was determined that no significant effects were expected on abundance and that, although there was some potential for effects on distribution, those effects are assessed as not significant.

The conclusions from the terrestrial assessment were adopted by the socio-economic assessment. Access to caribou considers features such as travel routes available for hunters to reach animals, opportunities to hunt and people's decisions to take advantage of those opportunities. Changes to caribou distribution could influence local harvesting. However, given that the Project effects on caribou are assessed as being not significant, distribution is not considered to be an important determinant of access in the socioeconomic assessment on harvesting. Maintaining the long-term viability of caribou populations will allow future generations of local harvesters are able the ability to successfully hunt caribou. Please refer to FEIS Volume 9, Part 1, Socio-Economic Environment, Section 9.1.2 Harvesting for more information.

There are several uncertainties about Project and cumulative effects on caribou and muskox that were discussed throughout this section. They include some information that is not known about future caribou movements, future caribou and muskox interaction with the Project, the response of harvesters to Project infrastructure, and the short-term impacts of long-term climate change scenarios. AREVA acknowledges the uncertainties, and addresses potential shifts and changes in wildlife interactions and responses within a continual improvement and adaptive management framework (Tier 3, Appendix 2T, and the management and mitigation actions outlined in the Wildlife Mitigation and Monitoring Plan in Tier 3, Appendix 6D.