APPENDIX XI.1

ENVIRONMENTAL HEALTH METHODS

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

1.0 INTRODUCTION

This appendix provides the detailed methods and results of the environmental health assessment. This assessment forms part of the overall environmental assessment (EA) for the Snap Lake Diamond Project proposed by De Beers Canada Mining Inc. (De Beers). The Snap Lake Diamond Project will be located at Snap Lake, Northwest Territories (NWT) approximately 220-km northeast of Yellowknife, NWT.

The environmental health impact assessment was based upon the results of the air quality, water quality, vegetation, and wildlife assessments. These results were used to evaluate the following:

- the potential for impacts to wildlife health from exposure to chemicals in air, water, snow, soil, and food; and,
- the potential for impacts to human health from exposure to chemicals in air, water, snow, soil, and traditional foods (fish, game, plants).

The terms of reference for environmental health are very general; therefore, additional guidance on key issues was sought from public consultation and traditional knowledge in order to address public concerns. The environmental health impact assessment evaluated the potential for long-term (or chronic) effects of chemical exposures on health. The maximum predicted concentrations of chemicals will not be high enough to cause short-term (acute) effects on health (*e.g.*, poisoning or acute allergy attacks). Wildlife mortality due to impact with vehicles and accidental spills is discussed in Section 10.4.

The following four exposure scenarios were evaluated:

- exposure to baseline chemical emissions from existing sources (*i.e.*, the baseline case);
- exposure to combined chemical emissions from baseline sources and the Snap Lake Diamond Project operational phase and closure phase (*i.e.*, the application case);
- exposure to cumulative chemical emissions from all existing, approved and planned developments (*i.e.*, the cumulative effects assessment ,CEA, case); and,
- exposure to chemical emissions post-closure (*i.e.*, the post-closure case)

The local study area (LSA) and the regional study area (RSA) used in the environmental health assessments are identical to those used for the wildlife habitat and vegetation assessments. Criteria for the selection of the LSA and RSA are defined in Sections 10.3 and 10.4 (refer to Figures 11.1-1 and 11.1-2 in Section 11 of the EA). Risk assessment was the primary tool used in the impact analysis. The risk assessment was carried out for valid linkages to evaluate whether activities associated with the Snap Lake Diamond Project might adversely impact health.

This appendix describes the risk assessment methods used to assess the impacts of the Snap Lake Diamond Project on environmental health. Sections 2 and 3 provide some basic information about risk assessment procedures. Section 4 presents the detailed information and methodology used in the wildlife health risk assessment. Detailed methodology for the human health risk assessment is presented in Section 5.

2.0 USE OF ENVIRONMENTAL RISK ASSESSMENT WITHIN THE IMPACT ASSESSMENT FRAMEWORK

Environmental risk assessments were conducted to evaluate whether activities associated with the Snap Lake Diamond Project might adversely affect human or wildlife health. The risk assessments were conducted according to established risk assessment protocols endorsed by Health Canada, the Canadian Council of Ministers of the Environment and the United States Environmental Protection Agency (U.S. EPA) (Health Canada [Unpublished] 1995; CCME 1997; U.S. EPA 1996). The risk assessment methods are discussed in Section 3 of this appendix.

The risk assessments answer the following key questions for environmental health:

EH-1 **What impacts will construction, operation, and closure of the Snap Lake Diamond Project have on wildlife health?**

EH-2 **What impacts will construction, operation, and closure of the Snap Lake Diamond Project have on human health?**

CEH-1 **What cumulative impacts will the Snap Lake Diamond Project and other regional developments have on wildlife health?**

CEH-2 **What cumulative impacts will the Snap Lake Diamond Project and other regional developments have on human health?**

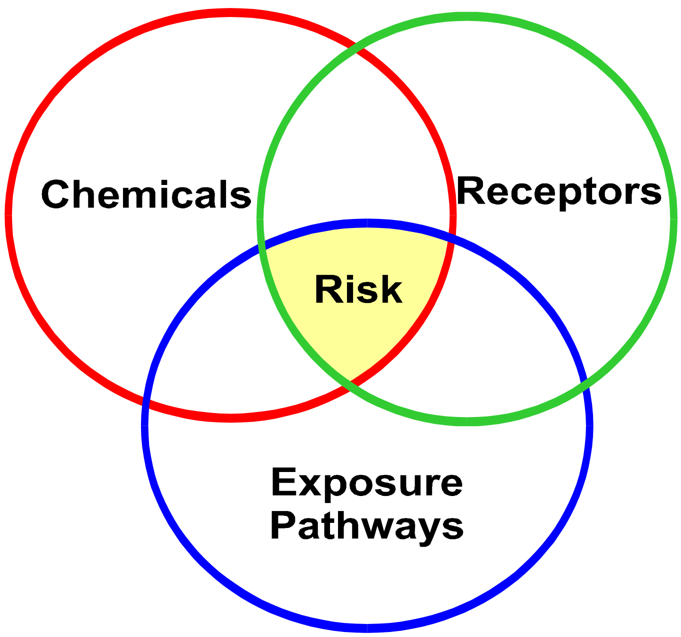
The first step in completing the impact assessments for environmental health was to determine whether a certain project-related activity has the potential to cause a change in environmental chemical exposure that might affect health. Each potential linkage between environmental changes and health was evaluated qualitatively to determine its validity based on specific activities of the Snap Lake Diamond Project (refer to Section 11.3). Subsequently, quantitative risk assessments were conducted for valid linkages, in which predicted exposures were compared to established toxicity reference values from regulatory agencies or the published literature. The overall risk assessment approach is summarized in the following section.

3.0 RISK ASSESSMENT FRAMEWORK

The potential for a health risk to arise from environmental substances is predicated on the co-existence of three elements (Figure XI.1-1):

- chemicals must be present at hazardous levels;
- receptors (*i.e.*, wildlife and/or people) must be present; and,
- exposure pathways must exist between the source of the chemicals and receptors.

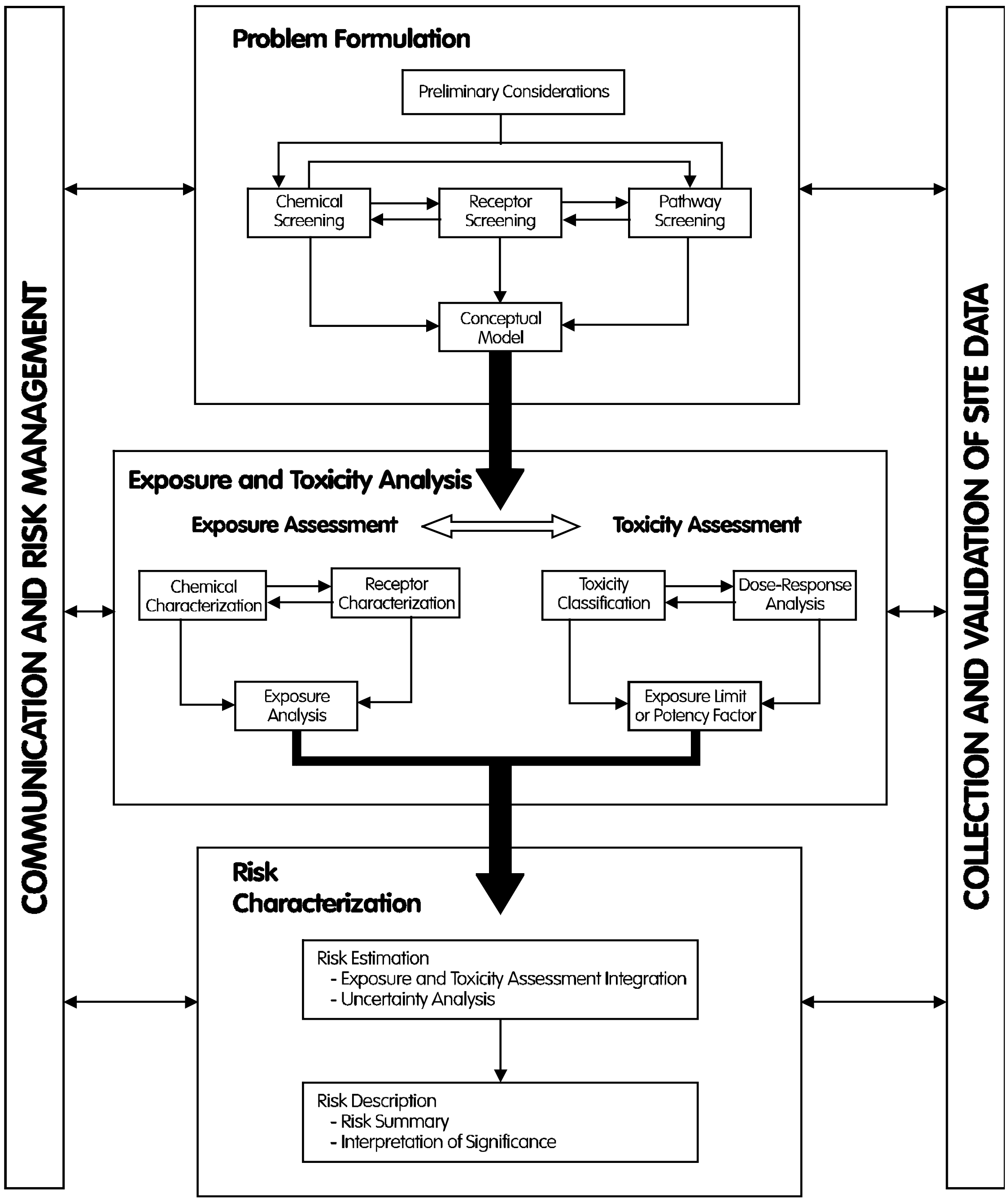
Figure XI.1-1
Three Elements of Environmental Risk



In the absence of any one of the three elements, health risks cannot occur. The presence of all three elements indicates a potential for risks to health, but does not necessarily indicate an unacceptable risk. In such situations, a risk assessment is completed to address both the magnitude and uncertainty associated with potential health risks.

The process followed a widely recognised framework for environmental health risk assessment, as illustrated in Figure XI.1-2 (Health Canada [Unpublished] 1995). The framework progresses from a qualitative initial phase (problem formulation), through exposure and toxicity analysis, and culminates in quantitative risk characterization.

Figure XI.1-2
Risk Assessment Framework



Source: Health Canada [Unpublished] 1995.

3.1.1 Problem Formulation

The objective of the problem formulation for this assessment was to develop a focused understanding of how chemicals emitted from the Snap Lake Diamond Project might affect health within the study areas. This was achieved by considering the components of the Snap Lake Diamond Project that might affect environmental health within the study areas. In addition, the assessment was focused on the wildlife and human activity that is expected to occur within the study areas, the chemicals that may be hazardous, and the plausible exposure pathways between chemicals and receptors.

The problem formulation helps to focus the risk assessment on the chemicals, receptors and exposure pathways of greatest concern (*i.e.*, chemicals with the greatest toxic potential; receptors with the greatest likelihood of being exposed and the greatest susceptibilities; exposure pathways that account for the majority of exposure to the chemicals emitted). If no unacceptable health risks are predicted for these, it is highly likely that unacceptable health risks would not exist for other chemicals, receptors, or exposure pathways. Specific components of the problem formulation are described in Section 3.1.1.1.

3.1.1.1 Components of Problem Formulation

The three components of problem formulation are:

(i) Receptor screening: The objective of the receptor screening process is to select a representative set of receptors that may be exposed to chemicals emitted by the Snap Lake Diamond Project. Representative receptors are those that would be at greatest risk, that play a key role in the food web (for wildlife), and that have sufficient characterization data to facilitate calculations of exposure and health risks. Wildlife receptors were also selected to include animals that are highly valued by local people and that are a food source for people.

(ii) Chemical screening: The objective of chemical screening is to focus on the chemicals of greatest concern emitted by the Snap Lake Diamond Project. Chemicals that do not increase in concentration as a result of the project, that do not exceed applicable guidelines/criteria, and/or that are essential nutrients with very low toxicity were removed from consideration. The remaining chemicals, which have the potential to contribute to increased health risks, were evaluated in the risk assessment.

(iii) Exposure pathway screening: The objective of exposure pathway screening is to determine all of the potential routes by which people and wildlife receptors could be exposed to chemical emissions from the Snap Lake Diamond Project. A list of plausible exposure pathways was developed. The list was then evaluated to determine whether each pathway would be operable for each receptor. For example, the water exposure pathway may be operable for all wildlife species, but the snow exposure pathway may only be operable for wildlife species that reside within the LSA or RSA during the winter.

The results of the problem formulation are presented as a conceptual exposure model. The conceptual exposure model is usually presented as a flowchart or pictorial illustration of the exposure pathways linking chemicals in various environmental media with the receptors of concern. The conceptual model for this assessment is shown in Figures XI.1-3 and XI.1-4 of this appendix.

3.1.2 Exposure Assessment

Exposure assessment is the process of estimating the amount of a chemical a receptor may take into its body (referred to as a dose) through all applicable exposure pathways. The dose of a chemical depends on the concentration in various media (*e.g.*, air, water, soil, food), the amount of time a receptor is in contact with these media and the biological characteristics of the receptor (*e.g.*, ingestion rates, body weights, dietary preferences).

Exposure assessment requires the use of predictive models. The models incorporate key parameters such as:

- chemical concentrations in environmental media;
- release rates from the media (*e.g.*, air deposition rates);
- uptake coefficients describing uptake from air, soil or water;
- transfer factors between different trophic levels; and,
- receptor characteristics, such as body weight, food ingestion rates, and time spent in the study area.

The chemical concentrations used in the exposure assessment models for the current assessment were both measured (*i.e.*, for baseline conditions) and predicted (*i.e.*, for future concentrations based on the proposed activities associated with the Snap Lake Diamond Project).

Figure XI.1-3
Potential Exposure Pathways

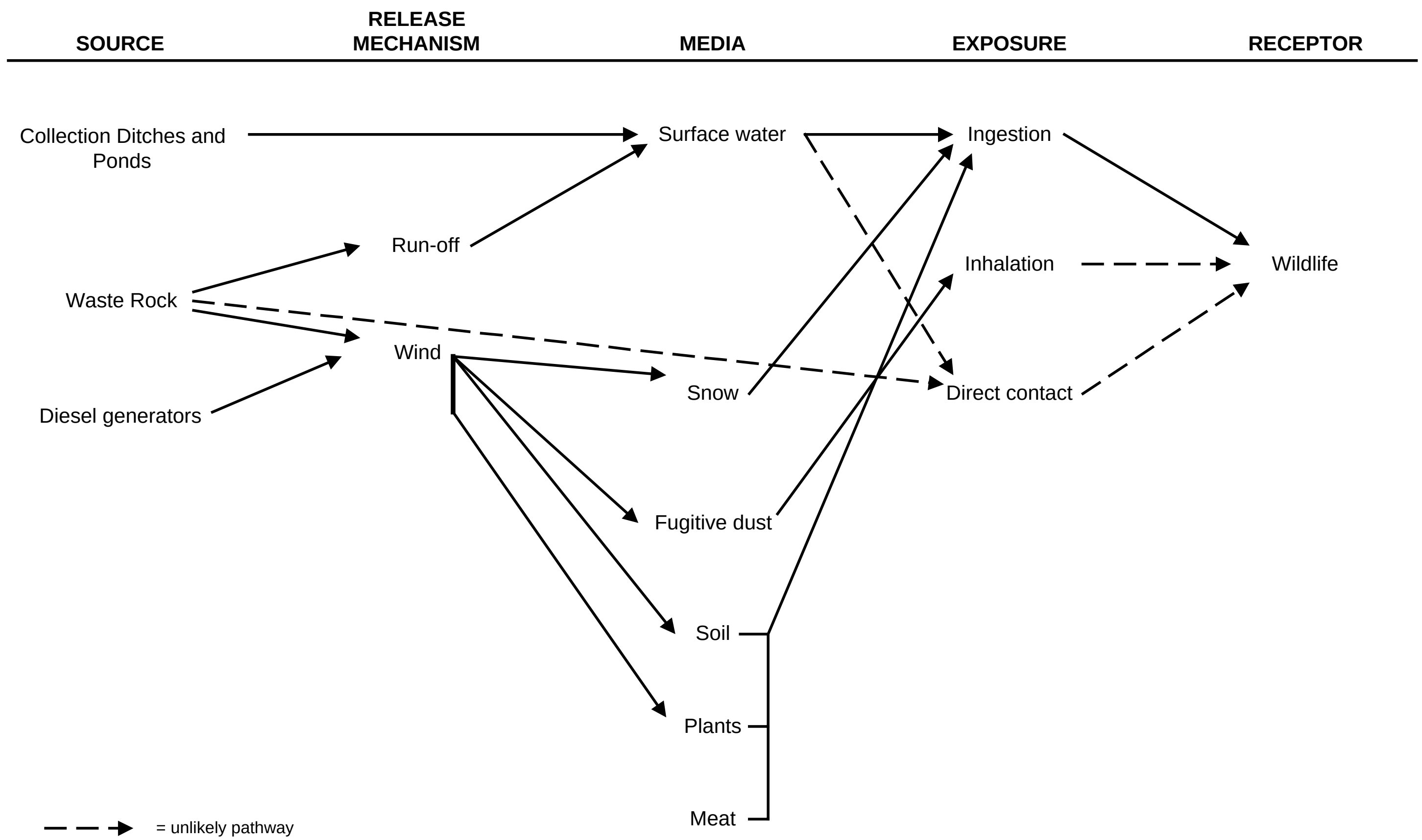
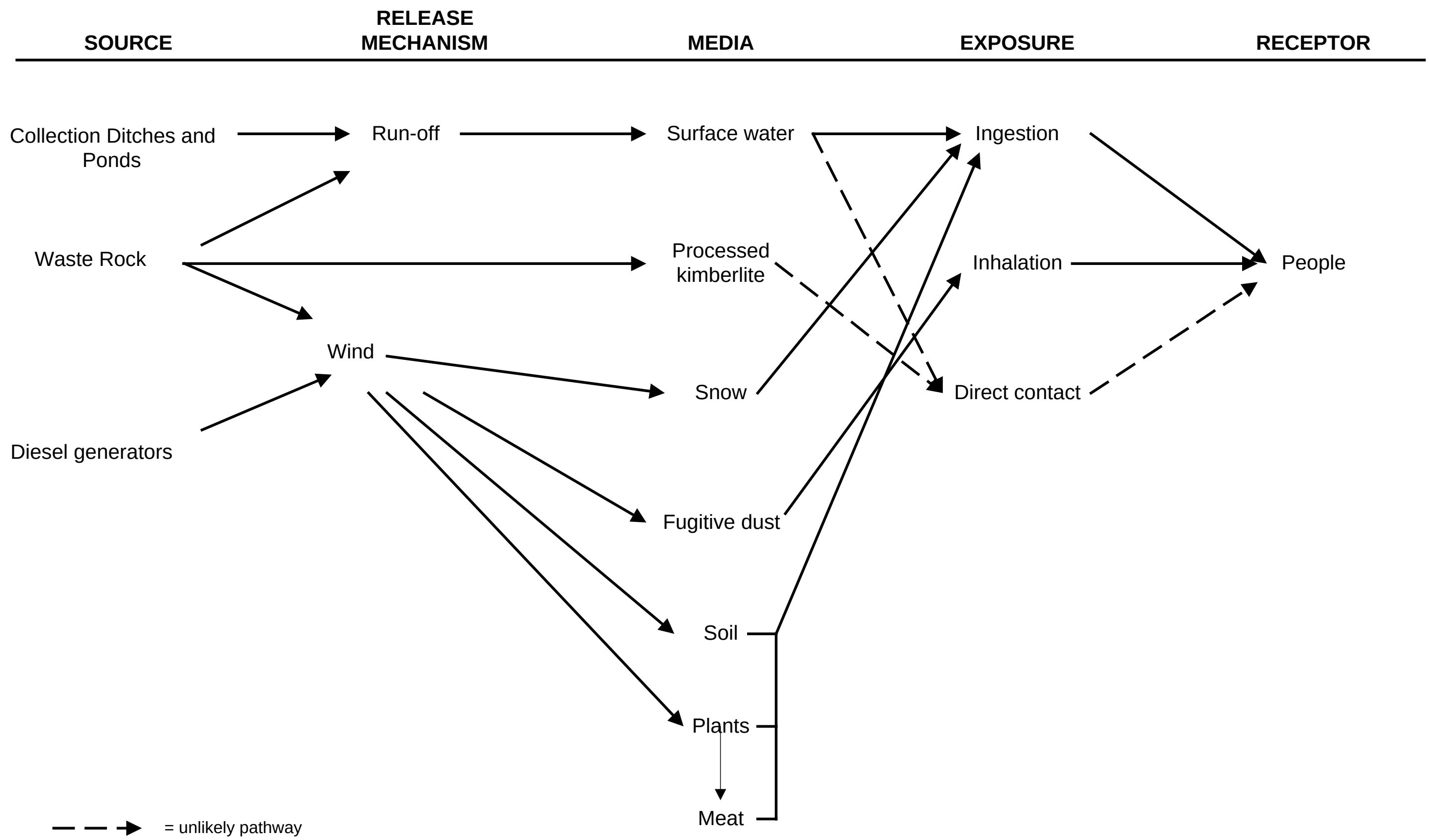


Figure XI.1-4
Exposure Pathway for Human Health



The following site-specific baseline chemical data were used in the exposure assessments for environmental health:

- water quality: measured metal concentrations in Snap Lake, MacKay Lake, and a reference lake;
- snow: measured chemical concentrations in snow within the RSA (used to represent the baseline case) and measured chemical concentrations in snow within the LSA (used to represent advanced exploration program (AEP) conditions);
- soil: measured chemical concentrations in soil within the RSA. Conditions within the LSA were assumed to be similar because it was not expected that significant accumulation of chemicals would occur from the AEP activities; and,
- lichen: measured chemical concentrations in lichen within the RSA. Conditions in the LSA were assumed to be similar because it was not expected that significant accumulation of chemicals would occur from the AEP.

Chemical concentrations in these media as a result of the Snap Lake Diamond Project were modelled and added to baseline concentrations to determine the chemical concentrations for the application case.

3.1.3 Toxicity Assessment

Toxicity assessment is the process of determining the amount of a chemical a receptor may take into its body (referred to as a dose) through all applicable exposure pathways without risk of adverse health effects. This parameter is typically referred to as a toxicity reference value.

For the human health assessment, toxicity reference values used to evaluate non-carcinogens are called reference doses (RfDs) or reference concentrations (RfCs; for inhalation) and describe a daily intake rate considered to be without adverse effects to susceptible members of the population over a lifetime. Toxicity reference values used in this assessment are based on dose-response toxicity evaluations available through agencies and toxicological databases, such as Health Canada and the integrated risk information system (IRIS), a U.S. EPA on-line database.

For wildlife health, toxicity information was obtained from toxicity studies using laboratory animals. Toxicity test species should ideally be the same species being studied, but this is rarely possible. Most often, mammalian toxicity studies are conducted with rats and mice, while avian toxicity studies are conducted with chickens or mallard ducks. Therefore, extrapolation of toxicity data between species, endpoints or laboratory/field data is necessary, although it contributes a large uncertainty factor. This generally results in an overprediction of potential risks.

Typically, chronic and sub-chronic endpoints are measured in mammalian and avian toxicity tests. These endpoints include effects on growth, reproduction or blood chemistry changes. Two endpoints are typically reported in chronic toxicity tests: the lowest observable adverse effect level (LOAEL) and the no observed adverse effect level (NOAEL). A LOAEL is the lowest chemical dose tested at which toxic effects may begin to occur in the receptor. A NOAEL is the highest chemical dose tested at which toxic effects were not observed. For this risk assessment, the LOAEL was incorporated into the risk characterization step as the toxicity reference value. If a LOAEL was not available or not appropriate (*i.e.*, LOAEL based on mortality endpoint), a NOAEL was used. Use of a NOAEL results in a more conservative assessment.

3.1.4 Risk Characterization

The final step of the risk assessment involves comparison of the exposure estimate to the toxicity benchmark. The product of this comparison is called an exposure ratio (ER). The ER is calculated using the following equation:

$$ER = \frac{\text{Estimated exposure}}{\text{Benchmark dose}}$$

ERs less than one indicate that exposures to the chemicals of concern are unlikely to cause adverse effects to humans or wildlife. An ER greater than one indicates that there is a potential for adverse effects on human or wildlife health.

3.1.5 Uncertainty

There is always uncertainty associated with risk assessment predictions, depending on the quality, quantity and variability associated with available information. When information is uncertain, it is standard practice in a risk assessment to make assumptions that are biased towards safety. The uncertainties inherent in modelling exposures are compensated for by the conservative input parameters used. Collectively, these conservative assumptions weigh heavily towards ERs that over-estimate the true risk that is likely to be manifested by human and wildlife receptors due to the Snap Lake Diamond Project. Thus, there is a high degree of confidence that risks have not been underestimated in this risk assessment.

4.0 WILDLIFE HEALTH RISK ASSESSMENT

4.1 Problem Formulation

The problem formulation step includes receptor screening, chemical screening and exposure pathway screening processes that are applicable to the wildlife health assessment.

4.1.1 Receptor Screening

The objective of this step was to select a representative set of wildlife receptors that may be exposed to chemicals emitted by the Snap Lake Diamond Project. Representative receptors are those that have the greatest potential for exposure, that play a key role in the food web, and that have sufficient characterization data to facilitate calculations of exposure and health risks. Receptors were also selected to include animals that are highly valued by local people and that are a food source for people. Table XI.1-1 presents the wildlife receptors and their dietary composition.

Table XI.1-1
Wildlife Receptors and Associated Diets

Wildlife Receptor	Species	Main Dietary Components
Grizzly bear	*Urus arctos horribilis*	berries, caribou
Caribou	*Rangifer tarandus*	lichen, willow, herbs
Wolverine	*Gulo gulo*	caribou, small mammals
Fox (Arctic)	*Alopex lagopus*	small mammals
Wolf	*Canis lupus arctos*	caribou, small mammals
Peregrine falcon	*Falco peregrinus tundrius*	birds, waterfowl, small mammals
Ptarmigan	*Lagopus lagopus*	plant leaves, buds, flowers, mosses
Arctic ground squirrel	*Spermophilus parayii*	plant leaves, buds, flowers, seeds
Common loon	*Gavia immer*	fish
Mallard duck	*Anas platyrhynchos*	vegetation, invertebrates
Semi-palmated plover	*Charadrius semipalmatus*	invertebrates

The wildlife receptors selected for this assessment are the same as the valued ecosystem components (VECs) selected for the wildlife impact assessment (Section 10.4). The Arctic ground squirrel was added to the list of wildlife receptors because it is an important food source for wolves, foxes, grizzly bears, and wolverines. The grizzly bear, peregrine falcon and wolverine are designated as "species of special concern" in Canada (COSEWIC 2001).

4.1.2 Chemical Screening

The objective of the chemical screening step is to focus the list of chemicals measured in various media (*e.g.*, snow, water, soil, lichen) to those chemicals that may be a concern because of their concentrations and their potential to cause adverse health effects. Chemicals identified in this screening process were evaluated in the risk assessment. The screening process followed a step-wise process as presented in Figure XI.1-5.

Step One: Compile Baseline Data for LSA and RSA

Samples of snow, water, fish, soil and lichen were collected in the LSA and RSA. Chemical analyses were conducted on these samples to determine the current concentrations of metals and polycyclic aromatic hydrocarbons (PAHs) in the samples (*i.e.*, baseline conditions).

Baseline Snow Concentrations

Snow samples were collected within the LSA and RSA at two separate time periods. The first set of samples was collected in March 2001. A second set of samples was collected in May 2001 to investigate community concerns regarding a dark dust that appears on the snow during the spring. Therefore, the second set of samples was collected with the purpose of sampling "dirty" snow within the mine boundary. The arithmetic mean was calculated for both sets of data. If a concentration was less than the analytical detection limit, one of half of the detection limit was conservatively used in the mean calculations. Baseline snow data are presented in Table XI.1-2.

Baseline Soil and Lichen Concentrations

Soil and lichen samples were collected within the RSA. The RSA data were considered to be representative of the LSA because it was assumed that there has been insufficient time for significant deposition of chemicals onto soil and lichen during the operation of the AEP and because emissions from the AEP would be localized (refer to Air Section 7.2).

Figure XI.1-5
Process for Chemical Screening

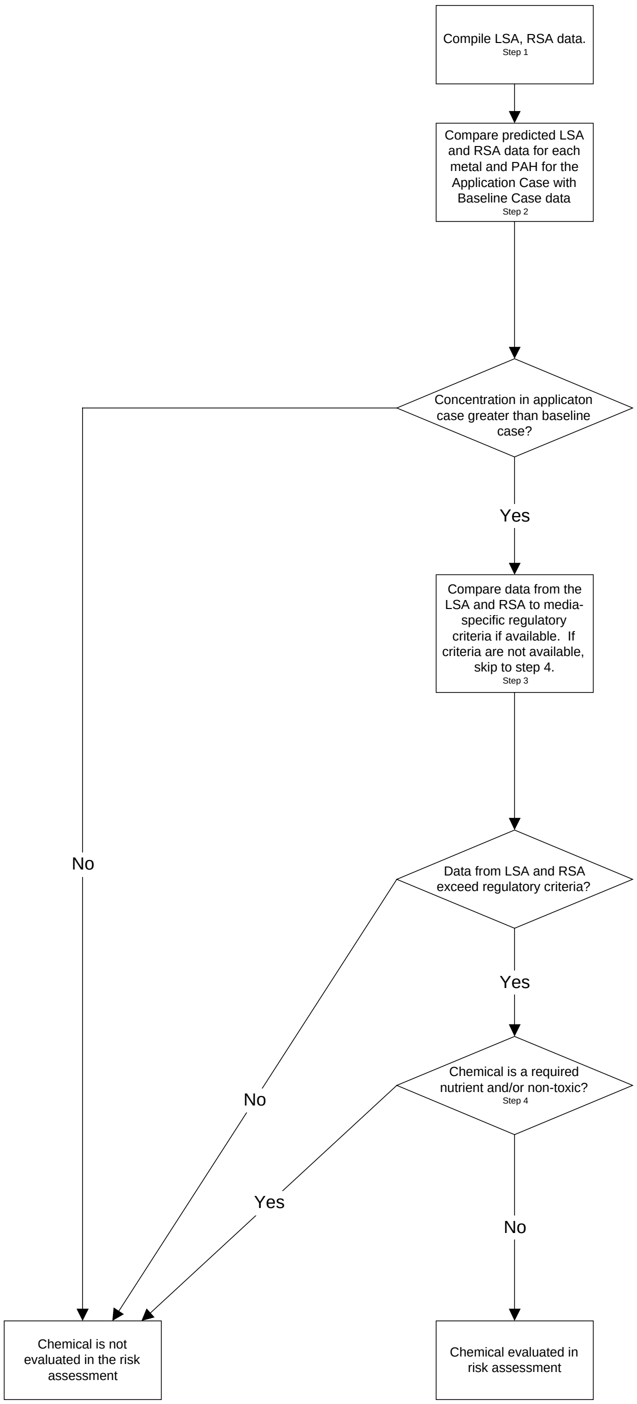


Table XI.1-2
Snow Baseline Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Snow within the Local Study Area and Regional Study Area

Chemicals	Mean Baseline Snow Concentration in LSA (mg/L)[1]	Mean Baseline Snow Concentration in RSA (mg/L)[2]
Total Metals [3]		
Aluminum	1.0	0.0093
Antimony	0.001	0.00003
Arsenic	0.000	0.00002
Barium	0.061	0.001
Boron	0.003	0.001
Calcium	1.410	0.191
Chromium	0.123	0.099
Cobalt	0.003	0.0002
Copper	0.004	0.0001
Iron	2.438	0.005
Lead	0.043	0.008
Magnesium	3.042	0.015
Manganese	0.161	0.024
Molybdenum	0.002	0.001
Nickel	0.045	0.0003
Potassium	0.394	0.032
Sodium	0.164	0.058
Strontium	0.010	0.0005
Uranium	0.000	0.0001
Vanadium	0.003	0.0001
Zinc	0.020	0.019
Polycyclic Aromatic Hydrocarbons		
Benzo(a)anthracene	<0.10	<0.10
Benzo(a)pyrene	<0.10	<0.10
Benzo(b)fluoranthene	<0.10	<0.10
Benzo(k)fluoranthene	<0.10	<0.10
Dibenzo(a,h)anthracene	<0.10	<0.10
Indeno(1,2,3-cd)pyrene	<0.10	<0.10
Naphthalene	<0.10	<0.10
Phenanthrene	<0.10	<0.10
Pyrene	<0.10	<0.10
Quinoline	<0.10	<0.10

Notes: LSA = local study area; RSA = regional study area; mg/L = milligrams per litre.

[1] arithmetic mean of nine samples.

[2] arithmetic mean of 14 samples. When concentrations were less than detection limits, half detection limits were used to calculate the mean.

[3] detection limits could not be reported because total snow concentrations are the sum of the water and solids portion of the snow. The detection limits from each process cannot be consolidated to provide a single detection limit for total snow concentrations.

Baseline Water and Air Concentrations

Baseline water quality data were collected from 1998 to 2001. Water quality data from this program are presented in Section 9.4 and Table XI.1-3. Baseline concentrations of metals and PAHs in ambient air were not available (Section 7.2).

Metals were measured in snow, soil, and lichen. PAHs were measured in snow and soil, but not in lichen because it was assumed that atmospheric deposition of PAHs and accumulation in lichens under baseline conditions would be negligible. Metal and/or polycyclic aromatic hydrocarbon (PAH) data are presented in Tables XI.1-2, XI.1-3, XI.1-4, and XI.1-5.

Step Two: Compare Predicted Concentrations for the Application Case to the Baseline Data

Metal and PAH concentrations for the application case were modelled and compared to measured baseline concentrations (Table XI.1-6). Chemicals that were predicted to increase by greater than 5% during the application case were carried forward to the next step in the chemical screening process. Five percent is considered to be within analytical error. Negligible increases of less than 5% were not evaluated further in the risk assessment.

Application Case Air Concentrations

Predicted concentrations of metals and PAHs in ambient air are presented in Section 7.3. Since baseline air quality data were not available, air data could not be screened against baseline concentrations. Therefore, all chemicals were carried forward to step three of the chemical screening process.

Table XI.1-3
Surface Water: Baseline Concentration of Metals in Snap Lake and Regional Lakes

Metal	Local Study Area	Regional Study Area		Reference Lake Mean [4] (mg/L)
	Snap Lake Median [1] (mg/L)	MacKay Lake Mean [2] (mg/L)	The North Lake Mean [3] (mg/L)	
Aluminum	0.022	0.005	<0.030	<0.030
Antimony	0.0005	0.0002	0.0005	<0.0005
Arsenic	<0.0002	<0.00025	<0.0002	<0.0002
Barium	0.003	0.002	0.005	0.002
Beryllium	<0.0001	<0.0001	<0.0001	<0.002
Bismuth	<0.0001	<0.0001	<0.0001	<0.0004
Cadmium	<0.0001	0.000005	<0.0001	<0.0003
Cesium	<0.0001	0.00003	0.0001	<0.0004
Chromium	<0.002	0.00009	<0.002	<0.003
Cobalt	0.0001	<0.0001	0.0001	<0.001
Copper	0.001	0.0005	0.001	<0.002
Iron	0.00003	<0.00002	<0.00002	0.0004
Lead	0.0003	0.0001	0.0003	0.001
Lithium	0.001	0.001	0.001	<0.003
Manganese	0.003	0.001	0.002	0.004
Mercury	<0.00001	<0.01	<0.00001	<0.01
Molybdenum	<0.0001	0.00003	<0.0001	<0.001
Nickel	0.0003	0.0003	0.001	<0.001
Selenium	<0.0055	<0.001	<0.01	<0.010
Silver	<0.0001	<0.00005	<0.0001	<0.0003
Strontium	0.007	0.007	0.010	0.008
Thallium	<0.0001	<0.07	<0.0001	<0.0004
Titanium	<0.0002	<0.05	<0.0002	<0.003
Uranium	<0.0001	<0.07	<0.0001	<0.0003
Vanadium	<0.0001	<0.0001	<0.0001	<0.001
Zinc	<0.010	0.001	<0.010	<0.010

Notes: LSA = local study area; RSA = regional study area; mg/L = milligrams per litre.
[1] median of three to 33 samples; refer to Appendix IX.6 for complete details.
[2] arithmetic mean of four samples.
[3] arithmetic mean of six samples.
[4] arithmetic mean of three samples.

Table XI.1-4
Soil Baseline Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Soil

Chemical	Mean Baseline Soil Concentration[a] (mg/kg)	Detection Limit (mg/kg)
Metals		
Aluminum	9,976	10
Antimony	<0.1	0.1
Arsenic	1.4	0.1
Barium	80.2	0.5
Beryllium	<1	1
Cadmium	<0.5	0.5
Calcium	1,719	100
Chromium	43.4	0.5
Cobalt	5.9	1
Copper	21.5	1
Iron	12,524	100
Lead	<5	5
Magnesium	4,438	10
Manganese	109	20
Mercury	0.05	0.01
Molybdenum	1.8	1
Nickel	21.8	2
Phosphorus	396	10
Potassium	2,182	20
Selenium	0.1	0.1
Silver	<1	1
Sodium	271	100
Strontium	15.1	1
Thallium	<1	1
Tin	<5	5
Titanium	635	5
Vanadium	31	1
Zinc	38.7	0.5
Polycyclic Aromatic Hydrocarbons		
Benzo(a)anthracene	<0.05	0.05
Benzo(a)pyrene	<0.05	0.05
Benzo(b)fluoranthene	<0.05	0.05
Benzo(k)fluoranthene	<0.05	0.05
Dibenzo(a,h)anthracene	<0.05	0.05
Indeno(1,2,3-cd)pyrene	<0.05	0.05
Naphthalene	0.07	0.05
Pyrene	<0.05	0.05
Quinoline	<0.05	0.05

Notes: mg/kg = milligrams per kilogram.
[a] arithmetic mean of twenty samples that were collected in the regional study area.

Table XI.1-5
Lichen: Baseline Concentrations of Metals in Lichen

Chemical	Mean Baseline Concentration[a] (mg/kg)	Detection Limit (mg/kg)
Aluminum	937	4
Antimony	<0.04	0.04
Arsenic	0.29	0.2
Barium	41.77	0.08
Beryllium	<0.2	0.2
Cadmium	<0.08	0.08
Calcium	2,189	10
Chromium	8.56	0.2
Cobalt	0.49	0.08
Copper	2.46	0.08
Iron	507	2
Lead	1.06	0.04
Magnesium	505	2
Manganese	118	0.04
Mercury	0.06	0.01
Molybdenum	0.36	0.04
Nickel	5.14	0.08
Phosphorus	375	2
Potassium	1,464	2
Selenium	<0.2	0.2
Silver	<0.08	0.08
Sodium	326	2
Strontium	12	0.04
Thallium	<0.04	0.04
Tin	<0.08	0.08
Titanium	36	0.05
Vanadium	1.22	0.08
Zinc	26	0.2

Note: mg/kg = milligrams per kilogram.
[a] arithmetic mean of twenty samples that were collected in the regional study area.

Application Case Water Concentrations

Mine water discharge concentrations were predicted for the application case (Section 9.4). These data represent concentrations of emissions entering Snap Lake (*i.e.*, they do not include dilution resulting from contact with Snap Lake). Discharge will be emitted 200-m offshore of Snap Lake and within 150 metres of the discharge point, it is estimated that the dilution factor will be at least 30-fold. Since some of the receptors

Table XI.1-6
Surface Water: Comparison of Baseline Case and Application Case Concentrations of Metals in Snap Lake

Chemical	Baseline Case Median Concentration in Snap Lake [1] (mg/L)	Application Case Predicted Concentration for Mine Water Discharge to Snap Lake (mg/L)
Aluminum	0.022	0.14
Arsenic	<0.0002	0.001
Barium	0.003	0.3
Beryllium	<0.0001	0.0001[2]
Cadmium	<0.0001	0.00007[2]
Chromium	<0.002	0.0075
Cobalt	0.0001	0.0006
Copper	0.001	0.0031
Iron	0.00003	0.45
Lead	0.0003	0.00073
Manganese	0.003	0.03
Mercury	<0.00001	0.00008
Molybdenum	<0.0001	0.008
Nickel	0.0003	0.014
Selenium	0.0055	0.0006[2]
Silver	<0.0001	0.00006[2]
Strontium	0.007	1.5
Thallium	<0.0001	0.0001[2]
Uranium	<0.0001	0.0007
Vanadium	<0.0001	0.002
Zinc	<0.010	0.01

Notes: mg/L = milligrams per litre.
[1] median of three to 33 samples. Refer to Appendix IX.6 for complete details.
[2] predicted concentrations are at or less than analytical detection limits.
shaded cells indicate concentrations of metals that are >5% higher in the application case than the baseline case.

could potentially be exposed to the discharge area, it was conservatively assumed in the risk assessment that all receptors were exposed to undiluted mine water discharge, with the exception of the semi-palmated plover. Since semi-palmated plover are shore birds and only ingest invertebrates from the shore, a dilution factor of 30 was applied for semi-palmated plover exposure to Snap Lake shore water. This is still conservative since it is likely that mine water discharge will be diluted by a factor significantly greater than 30 by the time it reaches the shore (Section 9.4). Metal concentrations in regional lakes were not predicted because conditions in Snap Lake are considered to be the worst-case scenario for the application case. If no risks are predicted for Snap Lake, no risks would also be predicted for the other regional lakes.

For the post-closure case, water quality changes were predicted for lakes north of the Snap Lake Diamond Project (arbitrarily named the north lake and the northeast lake; Section 9.4). Changes to water quality were predicted to be greater for the north lake than the northeast lake; therefore, exposure to the north lake was evaluated in the impact assessment for the post-closure case as the worst case lake. The baseline case and post-closure case for the north lake are compared in Table XI.1-7.

Application Case Concentrations in Snow, Lichen and Soil

Incremental contributions from the project to metal and PAH concentrations in snow, lichen and soil were predicted based on predicted dust deposition rates (Section 7.3) and equations in Table XI.1-8. The incremental contributions from the project were then added to the baseline concentrations and used as the application case concentrations for the risk assessment. The post-closure case was not predicted for these media because air emissions will cease at closure (Air Quality Section 7.3). Therefore, snow, soil, and lichen will no longer be exposed to emissions from the Snap Lake Diamond Project.

Baseline case and application case comparisons for snow, soil, and lichen are presented in Tables XI.1-9 to XI.1-11.

Table XI.1-7
The North Lake: Comparison of Baseline Case and Post-Closure Case Concentrations of Metals in the North Lake

Chemical	Mean Baseline Case Concentration in the North Lake [1] (mg/L)	Predicted Post-Closure Case Concentration in the North Lake (mg/L)
Aluminum	<0.030	0.040
Antimony	0.0005	0.0005
Arsenic	<0.0002	0.0002[2]
Barium	0.0051	0.020
Beryllium	<0.0001	0.0002
Bismuth	<0.0001	0.0002
Cadmium	<0.0001	0.0001[2]
Chromium	<0.002	0.013
Cobalt	0.0001	0.0001[2]
Copper	0.001	0.001
Iron	<0.00002	0.029
Lead	0.0003	0.0003
Manganese	0.0024	0.0033
Mercury	<0.00001	0.00001[2]
Molybdenum	<0.0001	0.003
Nickel	0.0008	0.0004
Selenium	<0.01	0.0001[2]
Silver	<0.0001	0.0001[2]
Strontium	0.010	0.20
Thallium	<0.0001	0.0001[2]
Titanium	<0.0002	0.0006
Uranium	<0.0001	0.0001[2]
Vanadium	<0.0001	0.0003
Zinc	<0.010	0.01[2]

Notes: mg/L = milligrams per litre.
[1] mean of six samples. Detection limits reported in Appendix IX.6.
[2] at or below the detection limit.

Table XI.1-8
Equations for Predicting the Incremental Contributions of the Project to Metal and Polycyclic Aromatic Hydrocarbons Concentrations in Snow, Soil, and Lichen

Media	Equation
Snow	$C_{snow\ application} = \dfrac{\underline{C}_{baseline}}{DR_{baseline}} \times DR_{application}$
	$C_{snow\ application}$ = Predicted concentration in snow (mg/L) $\underline{C}_{baseline}$ = Measured concentration in snow (mg/L) $DR_{baseline}$ = Measured deposition rate in snow (kg/ha/yr) $DR_{application}$ = Predicted deposition rate in snow (kg/ha/yr)
Soil	SC = D x CF1 x CF2 x DT/(SD x BD)
	SC = Soil concentration (mg/kg dry wt) D = Deposition rate (g/ha/yr) CF1 = Conversion factor for hectares to square metres (ha/m^2) CF2 = Conversion factor for grams to milligrams (mg/g) DT = Deposition time (25 years) SD = Soil depth (0.15 m) BD = Bulk density (1600 kg/m^3)
Lichen	LC_d = D x CF1 x CF2 x CF3 x DT x R / (S x Y)
	LC_d = Lichen concentration from deposition (mg/kg dry wt) D = Deposition rate (g/ha/yr) CF1 = Conversion factor for hectares to square metres (ha/m^2) CF2 = Conversion factor for grams to milligrams (mg/g) CF3 = Conversion factor for wet weight to dry weight DT = Deposition time (three months per year) R = Intercept fraction; represents portion of chemical deposition intercepted by plants (0.15; Baes *et al.* 1984). S = Growing season (three months per year) Y = Crop yield (3 kg/m^2; Baes *et al.* 1984)

Notes: mg/L = milligrams per litre; kg/ha/yr = kilograms per hectare per year; mg/kg = milligrams per kilogram; g/ha/yr = grams per hectare per year; ha/m^2 = hectares per square metre; mg/g = milligrams per gram; m = metre; kg/m^3 = kilograms per cubic metre; kg/m^2 = kilograms per square metre.

Table XI.1-9
Snow: Comparison of Application Case Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Snow to Measured Baseline Concentrations

Chemical	Baseline		Application Case	
	Local Study Area Mean Snow Concentration (mg/L) [1]	Regional Study Area Mean Snow Concentration (mg/L) [2]	Local Study Area Predicted Snow Concentration (mg/L)	Regional Study Area Predicted Snow Concentration (mg/L)
Metals				
Aluminum	1.0	0.0093	1.1	0.01162
Antimony	0.001	0.00003	0.001	0.00004
Arsenic	0.0002	0.00002	0.0002	0.00003
Barium	0.061	0.001	0.063	0.001
Boron	0.003	0.001	0.003	0.0002
Calcium	1.410	0.191	1.446	0.197
Chromium	0.123	0.099	0.124	0.099
Cobalt	0.003	0.0002	0.003	0.0002
Copper	0.004	0.0001	0.004	0.00006
Iron	2.438	0.005	2.496	0.012
Lead	0.043	0.008	0.043	0.008
Magnesium	3.042	0.015	3.22	0.03
Manganese	0.161	0.024	0.163	0.024
Molybdenum	0.002	0.001	0.002	0.001
Nickel	0.045	0.0003	0.046	0.0004
Potassium	0.394	0.032	0.402	0.033
Sodium	0.164	0.058	0.164	0.058
Strontium	0.010	0.0005	0.010	0.0005
Uranium	0.0002	0.0001	0.0002	0.0001
Vanadium	0.003	0.0001	0.003	0.0001
Zinc	0.020	0.019	0.020	0.019
Polycyclic Aromatic Hydrocarbons (PAH)				
Naphthalene[3]	-[4]	-[4]	-[4]	-[4]

Notes:
[1] Arithmetic mean of 9 samples.
[2] Arithmetic mean of 14 samples.
[3] Naphthalene was used to represent PAHs since particulate dust is composed of 63% naphthalene.
[4] Concentrations of naphthalene were less than the analytical detection limit in the baseline case. Therefore, a concentration for the application case could not be calculated.
Note: Shaded cells indicate concentrations of metals that increased by >5% in the application case when compared to baseline case. mg/L = milligrams per litre.

Table XI.1-10
Soil: Comparison of Application Case Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Soil to Measured Baseline Concentrations

Chemical	Local Study Area and Regional Study Baseline Mean Concentration (mg/kg)[1]	Local Study Area Application Predicted Concentration (mg/kg)	Regional Study Area Application Predicted Concentration (mg/kg)
Metals			
Aluminum	9976	9976	9976
Antimony	<0.1	0.05[2]	0.05[2]
Arsenic	1.39	1.39	1.39
Barium	80.23	80.27	80.23
Beryllium	<1	-[3]	-[3]
Cadmium	<0.5	0.25[2]	0.25[2]
Calcium	1719	1720	1719
Chromium	43.41	43.43	43.41
Cobalt	5.85	5.85	5.85
Copper	21.48	21.48	21.48
Iron	12,524	12,525	12,524
Lead	3.10	3.10	3.10
Magnesium	4,438	4,442	4,438
Manganese	108.57	108.62	108.57
Mercury	0.05	0.05	0.05
Molybdenum	1.80	1.80	1.80
Nickel	21.81	21.84	21.81
Phosphorus	396.19	396.26	396.19
Potassium	2,182	2,183	2,182
Selenium	0.14	-[3]	-[3]
Silver	<1	0.50[2]	0.50[2]
Sodium	271.43	271.44	271.43
Strontium	15.10	15.10	15.10
Thallium	<1	0.50[2]	0.50[2]
Tin	<5	2.50[2]	2.50[2]
Titanium	635	635	635
Vanadium	30.76	30.76	30.76
Zinc	38.66	38.66	38.66
Polycyclic Aromatic Hydrocarbons			
Naphthalene	0.07	10.77	0.60

Notes: [1] Arithmetic mean of 20 samples. Detection limits presented in Table XI.1-4
[2] Predicted concentration is less than current analytical detection limits.
[3] Deposition rates were not predicted because it is not considered a component of kimberlite (Section 7.2).
Note: Shaded cells indicate concentrations of metals that increased by >5% in the application case when compared to baseline case. mg/kg – milligrams per kilogram.

Table XI.1-11
Lichen: Comparison of Application Case Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Lichen to Measured Baseline Concentrations

Chemical	Local Study Area and Regional Study Area Average Baseline Concentration (mg/kg)[1]	Local Study Area Average Application Case Concentration (mg/kg)	Regional Study Area Average Application Case Concentration (mg/kg)
Aluminum	937	938	937
Antimony	<0.04	0.02[2]	0.02[2]
Arsenic	0.29	0.29	0.29
Barium	41.8	41.9	41.8
Beryllium	<0.2	0.10[2]	0.10[2]
Cadmium	0.06	0.06	0.06
Calcium	2,189	2,192	2,189
Chromium	8.56	8.60	8.56
Cobalt	0.49	0.50	0.49
Copper	2.46	2.46	2.46
Iron	508	510	508
Lead	1.06	1.06	1.06
Magnesium	505	512	505
Manganese	118	118	118
Mercury	0.06	0.06	0.06
Molybdenum	0.36	0.36	0.36
Nickel	5.14	5.20	5.14
Phosphorus	375	375	375
Potassium	1,465	1,465	1,465
Selenium	<0.2	0.10[2]	0.10[2]
Silver	<0.08	0.04[2]	0.04[2]
Sodium	326	326	326
Strontium	12.08	12.09	12.08
Thallium	<0.04	0.02[2]	0.02[2]
Tin	<0.08	0.04[2]	0.04[2]
Titanium	36.03	36.08	36.03
Vanadium	1.22	1.23	1.22
Zinc	26.30	26.30	26.30
Naphthalene	-[3]	19.26	0.96

Note: [1] Arithmetic mean of 20 samples. Detection limits presented in Table XI.1-5.
[2] Predicted concentration is less than current analytical detection limits.
[3] Not measured in baseline samples. Assumed to be below detection as per soil samples.
Shaded cells indicate concentrations of metals that increased by >5% in the application case when compared to baseline case. mg/kg – milligrams per kilogram.

Step Three: Compare application case data that exceed baseline concentrations to media-specific regulatory criteria

The next step in the chemical screening process involved comparison of chemicals retained from step two to applicable regulatory criteria. If chemical concentrations for the application case exceeded regulatory criteria, they were carried forward to step four of the chemical screening process. In addition, if regulatory criteria were not available for a chemical, it was retained and carried forward to step four of the chemical screening process. The specific comparisons for each media are presented below.

Water/Snow

Water quality criteria were used to screen both surface water and snow data. No regulatory water quality guidelines specific to wildlife health are available. The Canadian water quality guidelines for the protection of agricultural water uses – livestock water (CCME 1999) were used to evaluate wildlife health for the screening process.

Water quality predictions were conducted for three surface water sources. Mine water discharge to Snap Lake and drainage from the north pile were predicted for the application case and water quality in the north lake was predicted for the post-closure case.

Water and snow data are compared to regulatory criteria in Tables XI.1-12 to XI.1-15. Shaded cells indicate the exceedances of the criteria.

Table XI.1-12
Snap Lake: Comparison of Predicted Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Snap Lake for the Application Case with Water Quality Guidelines for the Protection of Livestock

Chemical	Canadian Council of Ministers of the Environment Livestock Protection Water Quality Guideline[1] (mg/L)	Application Case Maximum Average Annual Concentration for Mine Water Discharge to Snap Lake (mg/L)
Aluminum	5	0.14
Arsenic	0.025	0.001
Barium	-	0.3
Cadmium	0.08	0.00007
Chromium	0.05	0.0075
Cobalt	1	0.0006
Copper	0.5	0.0031
Iron	5	0.4
Lead	0.1	0.00073
Manganese	-	0.03
Mercury	0.003	0.00008
Molybdenum	0.5	0.008
Nickel	1	0.014
Strontium	-	1.5
Uranium	0.2	0.0007
Vanadium	0.1	0.002
Zinc	50	0.014

Notes: [1] CCME 1999.
Shaded cell indicates that the metal was evaluated further because no criteria are available.
mg/L – milligrams per litre.

Table XI.1-13
Drainage Ditches: Comparison of Predicted Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Drainage Ditches Around the North Pile for the Application Case with Water Quality Guidelines for the Protection of Livestock

Chemical	Canadian Council of Ministers of the Environment Livestock Protection Water Quality Guideline [1] (mg/L)	Application Case Maximum Average Annual Concentration for Drainage Ditches Around the North Pile (mg/L)
Aluminum	5	8.02
Arsenic	0.025	0.0077
Barium	-	0.64
Beryllium	0.1	0.0026
Cadmium	0.08	0.0025
Chromium	0.05	0.24
Cobalt	1	0.019
Copper	0.5	0.057
Iron	5	21.53
Lead	0.1	0.02
Manganese	-	0.70
Mercury	0.003	0.00092
Molybdenum	0.5	0.13
Nickel	1	0.45
Selenium	0.05	0.019
Silver	-	0.00067
Strontium	-	1.30
Thallium	-	0.0017
Uranium	0.2	0.027
Vanadium	0.1	0.06
Zinc	50	0.084

Notes: [1] CCME 1999.

Shaded cell indicates that the metal was evaluated further because the predicted concentration exceeds regulatory criteria or because no criteria are available; mg/L = milligrams per litre.

Table XI.1-14
The North Lake: Comparison of Predicted Concentrations of Metals in the North Lake for the Post-Closure Case with Water Quality Guidelines for the Protection of Livestock

Chemical	Canadian Council of Ministers of the Environment Livestock Protection Water Quality Guideline[1] (mg/L)	Post-Closure Case Concentration in the North Lake (mg/L)
Aluminum	5	0.040
Barium	-	0.020
Beryllium	0.1	0.0002
Chromium	0.05	0.013
Iron	5	0.029
Manganese	-	0.0033
Molybdenum	0.5	0.003
Strontium	-	0.20
Titanium	-	0.0006
Vanadium	0.1	0.0003

Notes: [1] CCME 1999.

Shaded cell indicates that the metal was evaluated further because no criteria are available.; mg/L = milligrams per litre.

Table XI.1-15
Snow: Comparison of Predicted Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Snow for the Application Case with Water Quality Guidelines for the Protection of Livestock

Metal	Canadian Council of Ministers of the Environment Livestock Protection Water Quality Guideline[1] (mg/L)	Local Study Area Application Case Snow Concentrations (mg/L)	Regional Study Area Application Case Snow Concentrations (mg/L)
Aluminum	5	1.1	0.0116
Antimony	-	0.001	0.00004
Arsenic	25	0.0002	0.00003
Barium	-	0.1	0.001
Calcium	1000	1.4	0.2
Chromium	0.050	0.100	0.1000
Iron	5	2.5	0.0117
Magnesium	-	3.2	0.0346
Nickel	1.0	0.046	0.0004
Potassium	-	0.4	0.0332

Notes: [1] CCME 1999.

Shaded cells indicate that the metals were carried forward to the next screening step because no criteria are available; mg/L = milligrams per litre.

Soil

Only naphthalene was retained from step two of the chemical screening process. The *Canadian Soil Quality Guidelines for the Protection of Agricultural Land Uses* (CCME 1999) for naphthalene were used to screen naphthalene concentrations in soil for the application case. Napthalene concentrations for the application case are compared to the regulatory criteria in Table XI.1-16 (shaded cells indicate exceedances of the criteria).

Table XI.1-16
Soil: Comparison of Predicted Naphthalene Concentrations in Soil for the Application Case with Soil Quality Guidelines for the Protection of Livestock

Chemical	Canadian Council of Ministers of the Environment Agriculture Land Use Guideline [1] (mg/kg)	Local Study Area and Regional Study Area Baseline Mean Concentration (mg/kg)	Local Study Area Application Case Concentration (mg/kg)	Regional Study Area Application Case Concentration (mg/kg)
Naphthalene	0.1	0.07	1.14	0.12

Note: [1] CCME 1999.
Shaded cells indicate that the metals were evaluated further because predicted concentrations exceed the criterion; mg/kg = milligrams per kilogram.

Lichen

There are no regulatory criteria for lichen. Therefore, all metals and PAHs remaining in lichen from step two were carried forward to step four.

Air

There are no air quality regulatory criteria that are appropriate for wildlife. This is because air inhalation is typically a minor exposure pathway for wildlife compared to uptake through the food chain. Therefore, the air inhalation pathway was evaluated for only those chemicals that exceeded baseline concentrations and regulatory guidelines in other exposure media.

Waterfowl and Shorebirds

There are no applicable criteria protective of mallard ducks, loons and semi-palmated plover. Therefore, livestock and agricultural criteria were assumed to also be applicable to waterfowl and shorebirds.

Step Four: Evaluation of Required Nutrients or Non-toxic Chemicals

Certain chemicals may be eliminated from further consideration based on their importance as a dietary component or essential nutrient, or based on a general lack of toxic effects. Iron, magnesium and potassium can be eliminated from the list of chemicals for further evaluation due to dietary requirements as described below. In addition, titanium can be eliminated due to its inert characteristics.

Iron

Iron is an essential mineral that is important for carrying oxygen in blood cells to important tissues such as muscles. Iron is also important for enzyme function. Excessive iron intake from environmental sources is extremely unlikely, if not impossible, for wildlife (Puls 1994). Therefore, iron was not evaluated in the impact assessment.

Magnesium

Magnesium is an essential mineral that is important for biochemical reactions of cells and is a component of bone. It is also commonly found in grains. Excessive magnesium intake will not likely cause toxicity (Puls 1994). Excessive concentrations of magnesium salts may lead to diarrhea and dehydration but the doses required to cause these effects are much higher than were measured or predicted in soil, water, lichen and snow in the LSA and RSA. Therefore, magnesium was not evaluated in the impact assessment.

Potassium

Potassium is an essential nutrient that is important for muscle contraction, nervous system maintenance and pH balance. It is naturally abundant and it is considered impossible to receive an excessive exposure to potassium from environmental sources (Puls 1994). Therefore, potassium was not evaluated in the impact assessment.

Titanium

Titanium was predicted to increase in concentration in the north lake for the post-closure case. However, titanium is an inert metal. Chronic toxicity studies reviewed by the World Health Organization (WHO 1982) indicate that long term exposure to titanium does not result in adverse health effects. Two long-term studies of rats exposed to titanium in drinking water showed no differences in survival or microscopic cellular changes between exposed and control animals (WHO 1982). Due to the lack of toxicity associated with titanium exposure and the general acceptance of the inert properties of titanium, it was not evaluated further in the impact assessment.

Final Chemical List

The remaining chemicals formed the final list of chemicals evaluated in the wildlife health risk assessment (Table XI.1-17). Although these chemicals did not consistently screen on in every media evaluated, the concentrations of these chemicals in all relevant media were used in the risk assessment to determine total exposures for the wildlife receptors. An exception is antimony. Antimony was measured in snow in the LSA (0.001 milligrams per litre [mg/L]) and in the RSA (0.00003 mg/L). However, antimony was not detected in any other media. In addition, antimony was not included in water quality predictions application case. There are no regulatory guidelines for antimony, nor is there sufficient information for food intake modelling for antimony. For these reasons, antimony was not evaluated further in the wildlife health assessment and is unlikely to pose a health risk to wildlife.

Table XI.1-17
Final List of Chemicals Evaluated in the Wildlife Health Risk Assessment and the Media in Which the Chemical Screened On

Chemical	Snow	Lichen	Water (Snap Lake)	Water (Drainage Ditches around North Pile)	Soil	Post-Closure Case for the North Lake
Aluminum				✔		
Barium	✔		✔	✔		✔
Chromium				✔		
Manganese			✔	✔		✔
Strontium			✔	✔		✔
Thallium				✔		
Naphthalene	✔	✔			✔	

4.1.3 Exposure Pathway Screening

The objective of screening exposure pathways is to identify potential routes by which wildlife could be exposed to chemicals and the relative significance of these pathways to total exposure. A chemical represents a potential health risk only if it can reach receptors through an exposure pathway at a concentration that could potentially lead to adverse effects. If there is no pathway for a chemical to reach a receptor, then there cannot be a risk, regardless of the chemical concentration. Figure XI.1-3 presents the potential exposure pathways for the wildlife health assessment. Each of these exposure pathways is evaluated below.

Ingestion of Surface Water

Chemicals may impact surface water, such as Snap Lake, via deposition of fugitive dust and discharge of treated mine and process plant water. Wildlife may be exposed to chemicals in surface water if they drink from these sources. In addition, some animals may drink from drainage ditches that collect run-off from the north pile. Therefore, this pathway was evaluated for the application case. It was assumed that wildlife could use Snap Lake and/or drainage ditches as drinking water sources for the application case. During the post-closure case, water quality in the north lake may be affected by groundwater seepage (see Section 9.4). Therefore, exposure to water in the north lake was assumed for the post-closure case.

Direct contact with Surface Water

Although wildlife may be exposed by directly contacting surface water, birds, fur-bearing mammals, small mammals and ungulates likely receive insignificant doses through this route relative to other routes, such as direct ingestion of water (Environment Canada 1994). Therefore, this pathway was not evaluated for the application or post-closure cases.

Ingestion of Snow

Throughout the winter months, snow is an important source of water for wildlife. Dust deposition on snow may result in increased concentrations of chemicals. Therefore, this pathway was evaluated for wildlife receptors that would be present within the study area during all or part of the winter (*i.e.*, caribou, wolverine, wolf, fox, and ptarmigan) for the application case. This pathway was not evaluated for the post-closure case, since chemical emissions from the Snap Lake Diamond Project will cease after closure.

Direct contact with Processed Kimberlite

Wildlife may be directly exposed to processed kimberlite by standing or lying on storage piles. However, due to the thick layer of keratin on hooves and paws and due to the presence of fur or feathers, uptake of chemicals would not likely occur (Suter 1993). Therefore, this pathway was not evaluated for the application or post-closure cases.

Ingestion of Fish

Dust deposition on waterbodies or direct discharge of treated mine and process water to Snap Lake may contribute to increased exposure of fish and aquatic invertebrates to metals and PAHs. These chemicals may then be taken up by fish and aquatic invertebrates and stored in their tissues. Wildlife (*e.g.*, loons) may then ingest these aquatic organisms. Therefore, this exposure pathway was evaluated for loons in the risk assessment for the application case and post-closure case.

Inhalation of Dust in Air

Wildlife may inhale fugitive dust that contains chemicals. Inhalation is a relatively minor exposure pathway for wildlife compared to ingestion of water, prey, and plants. Since baseline concentrations of metals and PAHs in air were not available, only predicted concentrations for the application case were used in the assessment. Inhalation of dust in air was evaluated as an exposure pathway in the impact assessment for the application case. This pathway was not evaluated for the post-closure case, since airborne emissions from the Snap Lake Diamond Project will cease after closure.

Ingestion of Plants

Fugitive dust emissions from the Snap Lake Diamond Project may deposit directly onto plant surfaces. Consuming plants could expose herbivorous wildlife to chemicals. Therefore, this exposure pathway was evaluated in the impact assessment for herbivorous wildlife receptors (*i.e.,* caribou, ptarmigan, grizzly bear, Arctic ground squirrel) for the application case. This pathway was not evaluated for the post-closure case, since airborne emissions from the Snap Lake Diamond Project will cease after closure.

Ingestion of Soil

Fugitive dust emissions from the Snap Lake Diamond Project may deposit directly onto soil. All wildlife species consume small amounts of soil during foraging, preening and grooming. Therefore, this exposure pathway was evaluated in the impact assessment for the application case. This pathway was not evaluated for the post-closure case, since airborne emissions from the Snap Lake Diamond Project will cease after closure.

Ingestion of Prey

Carnivorous and omnivorous animals have the potential to be exposed to chemicals from their prey. Consumption of prey is a potential exposure pathway for grizzly bears, wolves, wolverines, foxes and peregrine falcons. For this reason, ingestion of prey was evaluated in the impact assessment for these receptors for the application case. This pathway was not evaluated for the post-closure case, since airborne emissions from the Snap Lake Diamond Project will cease after closure.

The exposure pathways evaluated in the impact assessment for each receptor are presented in Table XI.1-18.

Table XI.1-18
Exposure Pathways Evaluated in the Risk Assessment

Receptor	Inhalation of Airborne Particulates	Ingestion of Soil	Ingestion of Surface Water	Ingestion of Snow	Ingestion of Plants	Ingestion of Prey
Grizzly bear	✔	✔	✔	✔	✔	✔
Caribou	✔	✔	✔	✔	✔	
Wolf	✔	✔	✔	✔		✔
Wolverine	✔	✔	✔	✔		✔
Fox	✔	✔	✔	✔		✔
Ptarmigan	✔	✔	✔	✔	✔	
Peregrine falcon	✔	✔	✔			✔
Arctic ground squirrel	✔	✔	✔	✔	✔	
Common loon	✔		✔			✔
Mallard duck	✔	✔	✔		✔	
Semi-palmated plover	✔	✔	✔			✔

4.2 Exposure Assessment

4.2.1 Spatial and Temporal Boundaries

The wildlife health exposure assessment uses the timeline for the application case of the Snap Lake Diamond Project during which the project is in operation (22 years).

The amount of time each receptor was assumed to spend within the LSA and/or RSA was based on the home range of the receptor compared to the size of the LSA and RSA. For small home range receptors (*i.e.*, Arctic ground squirrel, ptarmigan, fox), the area of the

LSA was often equal to or greater than the home range of these receptors. Therefore, these receptors were assumed to receive 100% exposure from soil, vegetation and/or prey from the LSA (Table XI.1-19).

Table XI.1-19
Time Spent by Wildlife Receptors in the Local Study Area and Regional Study Area (number of days they could be exposed to snow)

Valued Ecosystem Component	Time spent in Local Study Area (days per year)	Time spent in Regional Study Area (days per year)
Animals with Small Home Ranges		
Fox	365 (183)	365 (183)
Ptarmigan	365 (183)	365 (183)
Arctic ground squirrel	365 (183)	365 (183)
Animals with Large Home Ranges		
Grizzly	2 (1)	242 (30)
Wolf	2 (1)	181 (30)
Wolverine	2 (1)	363 (182)
Migratory Animals		
Caribou	1 (1)	182 (30)
Peregrine falcon	1 (0)	152 (0)
Common loon	124 (0)	124 (0)
Mallard duck	124 (0)	124 (0)
Semi-palmated plover	124 (0)	124 (0)

For receptors that have large home ranges (*i.e.*, grizzly bear, wolf, and wolverine), the area of the LSA was much less than the home range areas. Therefore, for these receptors, the amounts of time spent within the LSA and RSA were proportional to the fraction of the home range occupied by the LSA and RSA (Table XI.1-19). For example, the home range of a grizzly bear is 207,400 to 668, 500 ha (McLoughlin *et al.* 1999). The areas of the LSA and RSA are 1,407 ha and 301,907, respectively. Therefore, the LSA would constitute less than 1% of a grizzly bear home range. The RSA would constitute the remaining 99% of the grizzly bear home range. Therefore, the grizzly bear was assumed to spend 1% of its time feeding within the LSA and 99% of its time feeding within the RSA assuming habitat suitability in the LSA is similar to the RSA.

Since grizzly bears are not active during the winter months, the number of days that grizzly bears may be exposed to the chemicals of concern is equivalent to the number of days, on average, that they are active during the year.

Caribou, wolves, and peregrine falcons are migratory animals. Loons, mallard ducks and semi-palmated plovers are also migratory but could potentially inhabit a waterbody for the whole period that they are in the north. The time that migratory animals may be within the LSA and RSA was based on observation of these animals by the Wildlife Assessment team (Section 10.4). The amount of time spent in the LSA versus the RSA was expressed as a fraction of the areas of the LSA and RSA (Table XI.1-19).

4.2.2 Exposure Estimate Equations

Exposure estimate equations used for the wildlife health exposure assessments are presented in Table XI.1-20.

Table XI.1-20
Exposure Equations

Pathway	Equation and Equation Parameters
Water Ingestion (surface water and snow)	$EDI_{water} = \frac{IR \times BA \times C_{water} \times EF}{BW \times AT}$
	EDI_{water} = exposure due to ingestion of water (mg chemical/kg body weight - day) IR = ingestion rate (L/d) BA = oral bioavailability of chemical (assumed to be 1, unitless) C_{water} =chemical concentration in water or snow (mg/L) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year of possible exposure; 244days/year for grizzly bear; 365 days/year for other receptors)
Air Inhalation	$EDI_{air} = \frac{IR \times BA \times C_{air} \times EF}{BW \times AT}$
Soil Ingestion	$EDI_{soil} = \frac{IR \times BA \times C_{soil} \times EF}{BW \times AT}$
	EDI_{soil} = exposure due to ingestion of soil (mg chemical/kg body weight - day) IR = ingestion rate (kg/d) BA = oral bioavailability of chemical (assumed to be 1, unitless) C_{soil} = chemical concentration in soil (mg/kg) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year of possible exposure; 244days/year for grizzly bear; 365 days/year for other receptors)
Lichen Ingestion	$EDI_{lichen} = \frac{IR \times BA \times C_{lichen} \times EF}{BW \times AT}$
	EDI_{lichen} = exposure due to ingestion of lichen (mg chemical/kg body weight - day) IR = ingestion rate (kg/d) BA = oral bioavailability of chemical (assumed to be 1, unitless) C_{lichen} = chemical concentration in lichen (mg/kg) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year of possible exposure; 244days/year for grizzly bear; 365 days/year for other receptors)
Vegetation Ingestion	$EDI_{vegetation} = \frac{IR \times BA \times C_{vegetation} \times EF}{BW \times AT}$
	$EDI_{vegetation}$ = exposure due to ingestion of vegetation other than lichen (mg chemical/kg body weight - day) IR = ingestion rate (kg/d) BA = oral bioavailability of chemical (assumed to be 1, unitless) C_{lichen} = chemical concentration in vegetation (mg/kg) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year of possible exposure; 244days/year for grizzly bear; 365 days/year for other receptors)
Food Ingestion (*i.e.*, prey)	$EDI_{food} = \frac{IR \times BA \times C_{food} \times EF}{BW \times AT}$

Table XI.1-20
Exposure Equations (Continued)

Pathway	Equation and Equation Parameters
	EDI_{food} = exposure due to ingestion of prey (mg chemical/kg body weight - day) IR = ingestion rate (kg/d) BA = oral bioavailability of chemical (assumed to be 1, unitless) C_{food} = chemical concentration in food (mg/kg) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year of possible exposure; 244days/year for grizzly bear; 365 days/year for other receptors)

Note: mg/g – milligrams per gram; m = metre; kg/m^3 = kilograms per cubic metre; kg/m^2 – kilograms per square metre.

4.2.2.1 Concentration in Vegetation

Concentrations of metals and PAHs in vegetation other than lichen were calculated since ptarmigan, grizzly bears, mallard ducks, and Arctic ground squirrel eat plants other than lichen. Lichen only take up chemicals by deposition of fugitive dust. Other plants take up chemicals by both deposition of dust and by uptake through roots from soil. Therefore, the following equations were used to predict concentrations of metals and PAHs in rooted types of vegetation. Equation one was used to calculate the rooted plant concentrations from deposition of fugitive dust:

1. Plant Concentration of Metals and PAHs from Deposition of Fugitive Dust	PC_d = D x CF1 x CF2 x CF3 x DT x R / (S x Y)
	PC_d = Plant concentration from deposition (mg/kg) D = Deposition rate (g/ha/yr) CF1 = Conversion factor for hectares to square metres (ha/m^2) CF2 = Conversion factor for grams to milligrams (mg/g) CF3 = Conversion factor for wet weight to dry weight DT = Deposition time (3 months) R = Intercept fraction; represents portion of chemical deposition intercepted by plants (0.15; Baes *et al.* 1984). S = Growing season (3 months) Y = Crop yield (3 kg/m^2; Baes *et al.* 1984)

Note: g/ha/yr = ; ha/m^2; mg/g

Equation two was used to calculate rooted plant tissue concentrations from uptake through the roots:

2. Plant Concentration of Metals and PAHs from Uptake through Soil	PC_r =SC x BCF
	PC_r = Plant concentration from roots (mg/kg) SC = Soil concentration (mg/kg) BCF = Bioconcentration factor (chemical specific; unitless)

Note: mg/kg – milligrams per kilogram

Equation three was used to calculate the total plant tissue concentrations in rooted vegetation:

3. Total Plant Concentration	$PC_T = PC_d + PC_r$
	PC_T = Total plant tissue concentration (mg/kg) PC_d = Plant concentration from deposition (mg/kg) PC_r = Plant concentration from roots (mg/kg)

Note: mg/kg – milligrams per kilogram

Concentrations of metals and PAHs in prey were also calculated for carnivorous receptors. Concentrations of the metals in caribou and Arctic ground squirrel (representatives of large and small prey) were determined by multiplying the concentration in lichen or rooted vegetation by a bio-accumulation factor that converts the concentrations in plants to a typical concentration in meat of an animal that would forage on those plants. To determine concentrations in caribou meat, lichen concentrations were used as the plant source. To determine concentrations in small mammals, other rooted plants were used as the plant source. In addition, concentrations of metals in aquatic plants and invertebrates were determined for the diets of mallard and semi-palmated plover receptors. For the common loon, predicted fish tissue concentrations from Section 9.5 were evaluated. Bio-accumulation factors used for the calculations are presented in Table XI.1-21.

Table XI.1-21
Bioaccumulation Factors for the Uptake of Chemicals from Vegetation to Meat, Water to Aquatic Invertebrates and Water to Aquatic Vegetation

Chemical	Bioaccumulation Factor from Plants to Meat (unitless)[1]	Bioaccumulation Factor from Water to Aquatic Plants (unitless)[3]	Bioaccumulation Factor from Water to Aquatic Invertebrates (unitless)[3]
Aluminum	0.0015	7000	9542
Barium	0.00015	3 [4]	No data available
Chromium (III)	0.0055	791	31
Manganese	0.0004	492	2
Strontium	0.0003	3 [4]	No data available
Thallium	0.04	7000 [5]	9542
Napthalene	0.000056 [2]	No data available	No data available

Notes: [1] From Baes *et al.* 1984 (based on cattle feeding silage).
[2] From Travis and Arms 1988 (based on equation: $\log B_b = -7.735 + 1.033 \log K_{ow}$ and a K_{ow} of 3.37 for naphthalene.
[3] From U.S. EPA 2002.
[4] Based on data for cesium.
[5] Based on data for aluminum.

4.2.3 Wildlife Receptor Parameters

Details on the body weights, food ingestion rates, water ingestion rates, soil ingestion rates, inhalation rates and dietary compositions for each wildlife receptor evaluated in the wildlife health risk assessment are presented in Table XI.1-22.

Table XI.1-22
Wildlife Exposure Parameters Used in the Risk Assessment

Receptor	Diet	Weight (kg)	Food Ingestion Rate (kg/d dry matter)	Water/Snow Ingestion Rate (L/d)	Soil Ingestion Rate (kg/d)	Inhalation Rate (m^3/d)
Grizzly bear	50% vegetation 50% caribou[1]	363 [2,3]	8.72 [4]	19.91 [4]	0.24 [5]	60.88 [4]
Caribou	100% lichen [6]	118 [2,6]	3.46 [4]	7.23 [4]	0.07 [5]	24.75 [4]
Fox	100% small mammals (*i.e.*, Arctic ground squirrel) [6]	5.75 [6]	0.29 [4]	0.48 [4]	0.005 [7]	2.21 [4]
Wolverine	50% caribou 50% small mammals [6]	12.5 [3]	0.55 [4]	0.96 [4]	0.02 [8]	4.12 [4]
Wolf	50% caribou 50% small mammals [6]	70 [2]	2.26 [4]	4.53 [4]	0.063 [8]	16.33 [4]
Peregrine falcon	Conservatively assumed 100% small mammals (*i.e.*, Arctic ground squirrel) [6]	0.74 [6]	0.05 [4]	0.05 [4]	0.001 [7]	0.32 [4]
Ptarmigan	100% vegetation [6]	0.63 [6]	0.056 [4]	0.043 [4]	0.0043 [7]	0.29 [4]
Common loon	100% fish[6]	4.5 [6]	0.15 [2,4]	0.16 [2,4]	N/A	1.30 [4]
Mallard duck	100% vegetation[6]	1.13 [6]	0.08 [4]	0.056 [4]	0.002 [7]	0.45 [4]
Semi-palmated plover	100% invertebrates[6]	0.049 [9]	0.008 [4]	0.008 [4]	0.001 [7]	0.04 [4]
Arctic ground squirrel	100% vegetation[10]	0.78 [6]	0.049 [4]	0.05 [4]	0.0025 [11]	0.45 [4]

Notes: [1] Rob Gau, pers. comm., RWED
[2] B.C. MOELP 1996.
[3] RWED 2001.
[4] U.S. EPA 1993.
[5] Kroner and Cozzie 1999.
[6] Environment Canada 2001.
[7] Beyer *et al.* 1994.
[8] Based on data for fox from Beyer *et al.* 1994.
[9] Silva and Dunning 1995.
[10] World Wildlife Fund Canada 2001
[11] Based on data for prairie dogs from Beyer *et al.* 1994.
N/A – not applicable since loons do not eat soil
kg = kilogram; kg/d = kilograms per day; L/d = litres per day; m^3/d = cubic metres per day.

4.3 Toxicity Assessment

Aluminum

No specific data were identified regarding the oral toxicity of aluminum to mammalian wildlife. A LOAEL of 19.3 milligrams per kilogram per day (mg/kg/d) was reported for reproduction in laboratory mice that were exposed to aluminum in drinking water for three generations (Sample *et al.* 1996). Exposure was considered to be chronic because it was throughout three generations and occurred during a critical lifestage.

For this assessment, the chronic LOAEL for mice was used to estimate a receptor-specific LOAEL for mammalian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For grizzly bear, caribou, Arctic fox, wolf, wolverine, and Arctic ground squirrel, receptor-specific LOAELs of 11.0, 11.8, 14.1, 12.1, 13.4, 15.9 mg/kg-day, respectively, were derived.

No specific data were identified regarding the oral toxicity of aluminum to avian wildlife. A NOAEL of 109.7 mg/kg-day was reported for reproduction effects in laboratory ringed doves that were exposed to aluminum in the diet for four months (Sample *et al.* 1996). Exposure was considered to be chronic because it occurred during a critical lifestage.

For this assessment, the chronic NOAEL for ringed dove was used to estimate a receptor-specific NOAEL for avian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For mallard duck, common loon, peregrine falcon, semi-palmated plover and ptarmigan, receptor-specific NOAELs of 165, 217, 151, 88, and 146 mg/kg-day, respectively, were derived.

Barium

No specific data were identified regarding the oral toxicity of barium to mammalian wildlife. A NOAEL of 5.1 mg/kg-day was reported for growth and hypertension in laboratory rats that were exposed to barium chloride orally in water for 16 months (Sample *et al.* 1996). Exposure was considered to be chronic because it was more than one year.

For this assessment, the chronic NOAEL for rats was used to estimate a receptor-specific NOAEL for mammalian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For

Table XI.1-23
Derivation of Wildlife Toxicity Reference Values from Test Species Lowest Observable Adverse Effect Levels and No Observed Adverse Effect Levels

Chemicals	Test Species	Test Species Body Weight (kg)	Toxicological Endpoint	Test Species Lowest Observable Adverse Effect Level or No Observed Adverse Effect Level (mg/kg/d)	Estimated Wildlife Toxicity Reference Value (mg/kg/d)	Reference
Grizzly Bear						
Aluminum	Mouse	0.03	Reproduction [a]	19.3	11.0	Sample *et al.*, 1996
Barium	Rat	0.35	Growth, hypertension [b]	5.1	3.4	Sample *et al.*, 1996
Chromium (III)	Rat	0.35	Reproduction, longevity[b]	2,737	1,804	Sample *et al.*, 1996
Manganese	Rat	0.35	Reproduction [b]	284	187	Sample *et al.*, 1996
Strontium	Rat	0.35	Body weight, bone changes[b]	263	173	Sample *et al.*, 1996
Thallium	Rat	0.35	Reproduction [a]	0.074	0.05	Sample *et al.*, 1996
Naphthalene	Rat	0.35	Development [a]	450	297	Navarro *et al.* 1992
Caribou						
Aluminum	Mouse	0.03	Reproduction [a]	19.3	11.8	Sample *et al.*, 1996
Barium	Rat	0.35	Growth, hypertension [b]	5.1	3.6	Sample *et al.*, 1996
Chromium (III)	Rat	0.35	Reproduction, longevity[b]	2,737	1,930	Sample *et al.*, 1996
Manganese	Rat	0.35	Reproduction [b]	284	200	Sample *et al.*, 1996
Strontium	Rat	0.35	Body weight, bone changes[b]	263	185	Sample *et al.*, 1996
Thallium	Rat	0.35	Reproduction [a]	0.074	0.05	Sample *et al.*, 1996
Naphthalene	Rat	0.35	Development [a]	450	317	Navarro *et al.* 1992

Table XI.23
Derivation of Wildlife Toxicity Reference Values from Test Species Lowest Observable Adverse Effect Levels and No Observed Adverse Effect Levels (Continued)

Chemicals	Test Species	Test Species Body Weight (kg)	Toxicological Endpoint	Test Species Lowest Observable Adverse Effect Level or No Observed Adverse Effect Level (mg/kg/d)	Estimated Wildlife Toxicity Reference Value (mg/kg/d)	Reference
Mallard Duck						
Aluminum	Ringed dove	0.149	Reproduction [b]	110	165	Sample *et al.*, 1996
Barium	Day-old chicks	0.121	Mortality [b]	20.8	32.5	Sample *et al.*, 1996
Chromium (III)	Black Duck	1.25	Reproduction [a]	5	4.9	Sample *et al.*, 1996
Manganese	Japanese quail	0.072	Growth, behaviour [b]	977	1,695	Sample *et al.*, 1996
Common Loon						
Aluminum	Ringed dove	0.149	Reproduction [b]	110	217	Sample *et al.*, 1996
Barium	Day-old chicks	0.121	Mortality [b]	20.8	42.9	Sample *et al.*, 1996
Chromium (III)	Black Duck	1.25	Reproduction [a]	5	6.5	Sample *et al.*, 1996
Manganese	Japanese quail	0.072	Growth, behaviour [b]	977	2,234	Sample *et al.*, 1996
Peregrine Falcon						
Aluminum	Ringed dove	0.149	Reproduction [b]	110	151	Sample *et al.*, 1996
Barium	Day-old chicks	0.121	Mortality [b]	20.8	29.9	Sample *et al.*, 1996
Chromium (III)	Black Duck	1.25	Reproduction [a]	5	4.5	Sample *et al.*, 1996
Manganese	Japanese quail	0.072	Growth, behaviour [b]	977	1,557	Sample *et al.*, 1996
Arctic Fox						
Aluminum	Mouse	0.03	Reproduction [a]	19.3	14.1	Sample *et al.*, 1996
Barium	Rat	0.35	Growth, hypertension [b]	5.1	4.3	Sample *et al.*, 1996

Table XI.23
Derivation of Wildlife Toxicity Reference Values from Test Species Lowest Observable Adverse Effect Levels and No Observed Adverse Effect Levels (Continued)

Chemicals	Test Species	Test Species Body Weight (kg)	Toxicological Endpoint	Test Species Lowest Observable Adverse Effect Level or No Observed Adverse Effect Level (mg/kg/d)	Estimated Wildlife Toxicity Reference Value (mg/kg/d)	Reference
Chromium (III)	Rat	0.35	Reproduction, longevity[b]	2,737	2,314	Sample *et al.*, 1996
Manganese	Rat	0.35	Reproduction [b]	284	240	Sample *et al.*, 1996
Strontium	Rat	0.35	Body weight, bone changes[b]	263	222	Sample *et al.*, 1996
Thallium	Rat	0.35	Reproduction [a]	0.074	0.06	Sample *et al.*, 1996
Naphthalene	Rat	0.35	Development [a]	450	380	Navarro *et al.* 1992
Piping Plover						
Aluminum	Ringed dove	0.149	Reproduction [b]	110	88	Sample *et al.*, 1996
Barium	Day-old chicks	0.121	Mortality [b]	20.8	17.4	Sample *et al.*, 1996
Chromium (III)	Black Duck	1.25	Reproduction [a]	5	2.6	Sample *et al.*, 1996
Manganese	Japanese quail	0.072	Growth, behaviour [b]	977	905	Sample *et al.*, 1996
Willow Ptarmigan						
Aluminum	Ringed dove	0.149	Reproduction [b]	110	146	Sample *et al.*, 1996
Barium	Day-old chicks	0.121	Mortality [b]	20.8	28.9	Sample *et al.*, 1996
Chromium (III)	Black Duck	1.25	Reproduction [a]	5	4.4	Sample *et al.*, 1996
Manganese	Japanese quail	0.072	Growth, behaviour [b]	977	1,508	Sample *et al.*, 1996
Wolf						
Aluminum	Mouse	0.03	Reproduction [a]	19.3	12.1	Sample *et al.*, 1996
Barium	Rat	0.35	Growth, hypertension [b]	5.1	3.7	Sample *et al.*, 1996

Table XI.23
Derivation of Wildlife Toxicity Reference Values from Test Species Lowest Observable Adverse Effect Levels and No Observed Adverse Effect Levels (Continued)

Chemicals	Test Species	Test Species Body Weight (kg)	Toxicological Endpoint	Test Species Lowest Observable Adverse Effect Level or No Observed Adverse Effect Level (mg/kg/d)	Estimated Wildlife Toxicity Reference Value (mg/kg/d)	Reference
Chromium (III)	Rat	0.35	Reproduction, longevity[b]	2,737	1,992	Sample *et al.*, 1996
Manganese	Rat	0.35	Reproduction [b]	284	207	Sample *et al.*, 1996
Strontium	Rat	0.35	Body weight, bone changes[b]	263	191	Sample *et al.*, 1996
Thallium	Rat	0.35	Reproduction [a]	0.074	0.05	Sample *et al.*, 1996
Naphthalene	Rat	0.35	Development [a]	450	327	Navarro *et al.* 1992
Wolverine						
Aluminum	Mouse	0.03	Reproduction [a]	19.3	13.4	Sample *et al.*, 1996
Barium	Rat	0.35	Growth, hypertension [b]	5.1	4.1	Sample *et al.*, 1996
Chromium (III)	Rat	0.35	Reproduction, longevity[b]	2,737	2,209	Sample *et al.*, 1996
Manganese	Rat	0.35	Reproduction [b]	284	229	Sample *et al.*, 1996
Strontium	Rat	0.35	Body weight, bone changes[b]	263	212	Sample *et al.*, 1996
Thallium	Rat	0.35	Reproduction [a]	0.074	0.06	Sample *et al.*, 1996
Naphthalene	Rat	0.35	Development [a]	450	363	Navarro *et al.* 1992
Arctic ground squirrel						
Aluminum	Mouse	0.03	Reproduction [a]	19.3	15.9	Sample *et al.*, 1996
Barium	Rat	0.35	Growth, hypertension [b]	5.1	4.9	Sample *et al.*, 1996
Chromium (III)	Rat	0.35	Reproduction, longevity[b]	2,737	2,610	Sample *et al.*, 1996

Table XI.23
Derivation of Wildlife Toxicity Reference Values from Test Species Lowest Observable Adverse Effect Levels and No Observed Adverse Effect Levels (Continued)

Chemicals	Test Species	Test Species Body Weight (kg)	Toxicological Endpoint	Test Species Lowest Observable Adverse Effect Level or No Observed Adverse Effect Level (mg/kg/d)	Estimated Wildlife Toxicity Reference Value (mg/kg/d)	Reference
Manganese	Rat	0.35	Reproduction [b]	284	271	Sample *et al.*, 1996
Strontium	Rat	0.35	Body weight, bone changes[b]	263	251	Sample *et al.*, 1996
Thallium	Rat	0.35	Reproduction [a]	0.074	0.07	Sample *et al.*, 1996
Naphthalene	Rat	0.35	Development [a]	450	429	Navarro *et al.* 1992

Notes: [a] = lowest observable adverse effect level.
kg = kilogram; mg/kg/d = milligrams per kilogram per day.

grizzly bear, caribou, Arctic fox, wolf, wolverine, and Arctic ground squirrel, receptor-specific NOAELs of 3.4, 3.6, 4.3, 3.7, 4.1, and 4.9 mg/kg-day, respectively, were derived.

No specific data were identified regarding the oral toxicity of barium to avian wildlife. A NOAEL of 20.8 mg/kg-day was reported for mortality for day-old chicks that were exposed to barium hydroxide in the diet for four weeks (Sample *et al.* 1996).

For this assessment, the sub-chronic NOAEL for chicks was used as the NOAEL for wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For mallard duck, common loon, peregrine falcon, semi-palmated plover and ptarmigan, receptor-specific NOAELs of 32.5, 42.9, 29.9 17.4, and 28.9 mg/kg-day, respectively, were derived.

Chromium

No specific data were identified regarding the oral toxicity of chromium to mammalian wildlife. A NOAEL of 2,737 mg/kg-day was reported for reproduction and longevity in laboratory rats that were exposed to chromium orally in the diet (Sample *et al.* 1996). Exposure was considered to be chronic because it occurred during a critical lifestage.

For this assessment, the chronic NOAEL for rats was used to estimate a receptor-specific NOAEL for mammalian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For grizzly bear, caribou, Arctic fox, wolf, wolverine, and Arctic ground squirrel, receptor-specific NOAELs of 1804, 1930, 2314, 1992, 2209, and 2610 mg/kg-day, respectively, were derived.

No specific data were identified regarding the oral toxicity of chromium to avian wildlife. A LOAEL of 5 mg/kg-day was reported for reproduction effects in laboratory black ducks that were exposed to chromium in the diet for ten months (Sample *et al.* 1996). Exposure was considered to be chronic because it occurred during a critical lifestage.

For this assessment, the chronic LOAEL for black ducks was used to estimate a receptor-specific LOAEL for avian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For mallard duck, common loon, peregrine falcon, semi-palmated plover and ptarmigan, receptor-specific LOAELs of 4.9, 6.5, 4.5, 2.6, and 4.4, respectively, were derived.

Manganese

No specific data were identified regarding the oral toxicity of manganese to mammalian wildlife. A LOAEL of 284 mg/kg-day was reported for reproduction in laboratory rats that were exposed to manganese orally in the diet throughout gestation (Sample *et al.* 1996). Exposure was considered to be chronic because it occurred during a critical lifestage.

For this assessment, the chronic LOAEL for rats was used to estimate a receptor-specific LOAEL for mammalian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For grizzly bear, caribou, Arctic fox, wolf, wolverine, and Arctic ground squirrel, receptor-specific LOAELs of 187, 200, 240, 207, 229, and 271 mg/kg-day, respectively, were derived.

No specific data were identified regarding the oral toxicity of manganese to avian wildlife. A NOAEL of 977 mg/kg-day was reported for growth and behavioural effects in laboratory Japanese quail that were exposed to manganese in the diet for eleven weeks (Sample *et al.* 1996). Exposure was considered to be chronic because it occurred for longer than ten weeks.

For this assessment, the chronic NOAEL for Japanese quail was used to estimate a receptor-specific NOAEL for avian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For mallard duck, common loon, peregrine falcon, semi-palmated plover and ptarmigan, receptor-specific NOAELs of 1695, 2234, 1557, 905, and 1508, respectively, were derived.

Strontium

No specific data were identified regarding the oral toxicity of strontium to mammalian wildlife. A NOAEL of 263 mg/kg-day was reported for body weight and bone changes in laboratory rats that were exposed to strontium in drinking water for three years (Sample *et al.* 1996). Exposure was considered to be chronic because it occurred for three years.

For this assessment, the chronic NOAEL for rats was used to estimate a receptor-specific NOAEL for mammalian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For grizzly bear, caribou, Arctic fox, wolf, wolverine, and Arctic ground squirrel, receptor-specific NOAELs of 173, 185, 222, 191, 212 and 251 mg/kg-day, respectively, were derived.

No specific data were identified regarding the oral toxicity of strontium to avian receptors. Therefore, avian exposure to strontium could not be evaluated.

Thallium

No specific data were identified regarding the oral toxicity of thallium to mammalian wildlife. A LOAEL of 0.074 mg/kg-day was reported for reproductive effects in laboratory rats that were exposed to thallium in drinking water for 60 days (Sample *et al.* 1996). Exposure was considered to be sub-chronic because it occurred for less than three years and did not occur during a critical lifestage.

For this assessment, the chronic LOAEL for rats was used to estimate a receptor-specific LOAEL for mammalian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For grizzly bear, caribou, Arctic fox, wolf, wolverine, and Arctic ground squirrel, receptor-specific NOAELs of 0.05, 0.05, 0.06, 0.05, 0.06, and 0.07 mg/kg-day, respectively, were derived.

No specific data were identified regarding the oral toxicity of strontium to avian receptors. Therefore, avian exposure to strontium could not be evaluated.

Naphthalene

No specific data were identified regarding the oral toxicity of naphthalene to mammalian wildlife. A LOAEL of 450 mg/kg-day was reported for developmental effects (*i.e.*, fetal resorption and reduced fetal growth rates) in laboratory rats that were exposed to naphthalene by gavage during days 6 through 15 of gestation (Navarro *et al.* 1992). Exposure was considered to be chronic because it occurred during a critical lifestage.

For this assessment, the chronic LOAEL for rats was used to estimate a receptor-specific LOAEL for mammalian wildlife by adjusting the dose according to differences in body size as outlined in Sample and Arenal (1999) and summarized in Table XI.1-23. For grizzly bear, caribou, Arctic fox, wolf, wolverine, and Arctic ground squirrel, receptor-specific LOAELs of 297, 317, 380, 327, 363, 429 mg/kg-day, respectively, were derived.

No specific data were identified regarding the oral toxicity of strontium to avian receptors. Therefore, avian exposure to strontium could not be evaluated.

4.4 Risk Characterization

Tables XI.1-24 through XI.1-26 present the ERs for each receptor and chemical of concern for the baseline and application cases in the LSA and RSA and the post-closure case.

Table XI.1-24
Exposure Ratios for Wildlife that Inhabit both the Local Study Area and Regional Study Area

Metals	Baseline	Application
Caribou		
Aluminum	1.4	1.3
Barium	0.2	0.3
Chromium	0.00007	0.0003
Manganese	0.009	0.008
Strontium	0.001	0.001
Thallium	0.009	0.1
Naphthalene	0.00000007	0.00003
Grizzly bear		
Aluminum	1.1	1.3
Barium	0.1	0.2
Chromium	0.00005	0.00006
Manganese	0.005	0.007
Strontium	0.0006	0.0007
Thallium	0.008	0.01
Naphthalene	0.0000001	0.00004
Wolf		
Aluminum	0.4	0.4
Barium	0.01	0.01
Chromium	0.00001	0.00001
Manganese	0.0002	0.0002
Strontium	0.00004	0.00004
Thallium	0.004	0.005
Naphthalene	0.00000009	0.0000009
Wolverine		
Aluminum	1.2	1.2
Barium	0.03	0.03
Chromium	0.00003	0.00003
Manganese	0.0008	0.0008
Strontium	0.0001	0.0001
Thallium	0.01	0.01
Naphthalene	0.0000003	0.000003
Peregrine falcon		
Aluminum	0.04	0.04
Barium	0.00009	0.00009
Chromium	0.0006	0.006
Manganese	0.00004	0.00004
Strontium	- [1]	- [1]
Thallium	- [1]	- [1]
Naphthalene	- [1]	- [1]

Note: [1] Could not be calculated due to a lack of avian-specific toxicity information.

Table XI.1-25
Exposure Ratios for the Baseline and Application Cases for Wildlife that Live Entirely within the Local Study Area or Regional Study Area

Chemicals	Local Study Area		Regional Study Area	
	Baseline	Application	Baseline	Application
Fox				
Aluminum	0.6	0.7	0.6	0.6
Barium	0.02	0.02	0.02	0.02
Chromium	0.00002	0.00002	0.00002	0.00002
Manganese	0.0004	0.0006	0.0004	0.0004
Strontium	0.00006	0.0005	0.00006	0.00006
Thallium	0.007	0.009	0.008	0.008
Naphthalene	0.0000002	0.00002	0.0000002	0.000001
Arctic ground squirrel				
Aluminum	6.3	7.7	6.3	7.7
Barium	0.7	0.9	0.7	0.9
Chromium	0.0003	0.0004	0.0003	0.0004
Manganese	0.03	0.04	0.03	0.04
Strontium	0.004	0.005	0.004	0.004
Thallium	0.04	0.06	0.04	0.06
Naphthalene	0.0000005	0.004	0.0000005	0.0002
Ptarmigan				
Aluminum	0.9	1.0	0.9	1.0
Barium	0.1	0.2	0.1	0.2
Chromium	0.2	0.3	0.2	0.2
Manganese	0.006	0.008	0.006	0.008
Strontium	- [1]	- [1]	- [1]	- [1]
Thallium	- [1]	- [1]	- [1]	- [1]
Naphthalene	- [1]	- [1]	- [1]	- [1]
Mallard Duck				
Aluminum	0.06	0.2	0.04	0.04
Barium	0.001	0.002	0.001	0.002
Chromium	0.009	0.02	0.005	0.005
Manganese	0.00005	0.0001	0.00004	0.00004
Strontium	- [1]	- [1]	- [1]	- [1]
Thallium	- [1]	- [1]	- [1]	- [1]
Naphthalene	- [1]	- [1]	- [1]	- [1]
Common Loon				
Aluminum	0.0008	0.007	0.0009	0.0009
Barium	0.00004	0.005	0.00005	0.00005
Chromium	0.0003	0.002	0.0005	0.0005
Manganese	0.000006	0.00005	0.000004	0.000004
Strontium	- [1]	- [1]	- [1]	- [1]

Table XI.25
Exposure Ratios for the Baseline and Application Cases for Wildlife that Live Entirely within the Local Study Area or Regional Study Area (Continued)

Chemicals	Local Study Area		Regional Study Area	
	Baseline	Application	Baseline	Application
Thallium	- [1]	- [1]	- [1]	- [1]
Naphthalene	- [1]	- [1]	- [1]	- [1]
Semi-palmated Plover				
Aluminum	0.9	0.8	0.8	0.8
Barium	0.03	0.03	0.03	0.03
Chromium	0.1	0.1	0.1	0.1
Manganese	0.0008	0.0008	0.0008	0.0008
Strontium	- [1]	- [1]	- [1]	- [1]
Thallium	- [1]	- [1]	- [1]	- [1]
Naphthalene	- [1]	- [1]	- [1]	- [1]

Note: [1] Could not be calculated due to a lack of avian-specific toxicity information.

Table XI.1-26
Exposure Ratios for the Post-Closure Case for Wildlife that Could be Exposed to Water in the North Lake

Wildlife Receptor	Barium	Manganese	Strontium
Caribou	0.0000009	0.000000003	0.0000002
Grizzly Bear	0.0000009	0.000000002	0.0000002
Wolverine	0.000001	0.00000003	0.0000002
Fox	0.0002	0.0000005	0.00004
Arctic ground squirrel	0.0001	0.0000004	0.00003
Ptarmigan	0.00002	0.00000007	0.00003
Peregrine Falcon	0.0000001	0.0000000004	0.0000001
Mallard Duck	0.00005	- [1]	- [1]
Common Loon	0.0005	- [1]	- [1]
Semi-palmated Plover	0.00006	- [1]	- [1]

Note: [1] Could not be calculated due to a lack of avian-specific toxicity information

5.0 HUMAN HEALTH RISK ASSESSMENT

5.1 Problem Formulation

The first step in the problem formulation involved selection of applicable exposure scenarios (*i.e.*, activities conducted by people in the area that might bring them in contact with chemical emissions from the project). Following the selection of the exposure scenarios, appropriate receptors, chemicals and exposure pathways were selected.

5.1.1 Exposure Scenarios

Two different exposure scenarios were evaluated as follows:

- hunting scenario: direct exposures to chemical emissions from the project incurred by people while hunting or fishing within the LSA and/or RSA (*i.e.*, drinking water from Snap Lake, inhaling dust);
- community exposure scenario: exposures incurred by family members in nearby communities who eat foods obtained from the LSA or RSA (*e.g.*, plants, game meat). The nearest local community, Lutsel K'e, is located at a sufficient distance from the project such that it will not be directly impacted by air and water emissions from the project. Therefore, game meat and fish consumption is the only potential means of exposure to chemical emissions from the project for community members.

5.1.2 Receptor Screening

It was assumed that a toddler might accompany his/her parent on a hunting trip within the LSA and/or RSA and that a toddler may consume game meat obtained from hunting trips. Each life phase (*i.e.*, toddler life phase = age 7 months to 4 years; child life phase = age 5 to 11 years; adult life phase = age 20 to 70) was evaluated throughout the risk assessment because for each life phase, exposure rates and sensitivity to chemicals may vary. The risk assessment is protective of the entire family because the most conservative consumption rates for each life phase were used in the risk assessment. The adolescent life phase (12-19 years) was not specifically evaluated, but would be similar to the child life phase.

It is highly unlikely that families would be hunting within the LSA (*i.e.*, within 500 m of the lease boundary). However, evaluation of this maximally-exposed scenario is considered a conservative approach. If risk estimates are less than one than there is a high degree of certainty that health effects are not expected to occur.

5.1.3 Chemical Screening

Process

The chemical screening process followed the same steps as outlined in Section 4.1.2 of this appendix.

Step One: Compile baseline data for the LSA and RSA

Concentrations of snow, soil, and lichen presented in Section 4.1.2 of this appendix were used for the baseline assessment for human health. Lichen data were used as a surrogate for baseline traditional plant tissue concentrations, which were not available.

Step Two: Compare predicted application case concentrations to baseline data

Application case concentrations of metals and PAHs in environmental media used in the human health risk assessment are presented in Section 4.1.2 of this appendix. Predicted concentrations of metals and PAHs for the application case were compared to measured baseline concentrations (Table XI.1-6, Tables XI.1-9 to XI.1-11). Chemicals that were predicted to increase by greater than 5% during the application case were carried forward to the next step in the chemical screening process. Five percent was considered to be within analytical error. Negligible increases of less than 5% were not evaluated further in the risk assessment. Lichen were used as a surrogate for other plants. Since concentrations did not increase in the application case when compared with the baseline case, it is not expected that concentrations would increase in other plants.

Note that concentrations predicted for drainage ditches around the north pile were not evaluated in the human health assessment because humans will not consume water from the ditches.

Traditional Foods - Meat

Members of the nearest communities to Snap Lake consume caribou meat. Therefore, in addition to concentrations measured in soil, water, snow and lichen, concentrations of metals and PAHs were predicted for caribou meat for baseline and application cases (Table XI.1-27). These metals and naphthalene were the chemicals of concern for the wildlife health assessment. Because uptake factors from lichen to caribou meat are so low, the small predicted changes in lichen concentrations between application and baseline cases do not result in changes in caribou meat concentrations from the baseline to application case. Therefore, metals in caribou meat were not evaluated further in the impact assessment.

Naphthalene concentrations in caribou meat were predicted for the application case; however they could not be calculated for the baseline case because lichen samples were not measured for naphthalene. Since application case naphthalene concentrations in caribou meat could not be compared to baseline case concentrations, naphthalene in caribou meat was carried forward to step three of the chemical screening process.

Table XI.1-27
Predicted Concentrations in Caribou Meat

Chemical	Baseline (mg/kg)	Application Case (mg/kg)
Aluminum	1.41	1.41
Barium	0.006	0.006
Chromium	0.047	0.047
Manganese	0.047	0.047
Strontium	0.004	0.004
Thallium	0.0008	0.0008
Naphthalene	-	2.6

Notes: [1] Baseline naphthalene concentrations could not be calculated because lichen data for naphthalene was not available.
mg/kg = milligrams per kilogram.

Ambient Air

Predicted concentrations of metals and PAHs in ambient air are presented in Section 7.3. Since baseline air quality data were not available, air data could not be screened against baseline concentrations. Therefore, all chemicals were carried forward to step three of the chemical screening process.

Chemicals retained from step two and carried forward to step three of the chemical screening process are listed in Table XI.1-28.

Table XI.1-28
Chemicals Retained from Step Two

Chemical	Soil	Traditional Food (Meat)	Water	Snow	Lichen (Plants)	Air
Aluminum			✔	✔		✔
Antimony				✔		✔
Arsenic			✔	✔		✔
Barium			✔	✔		✔
Boron						✔
Cadmium			✔			✔
Calcium				✔		✔
Chromium			✔	✔		✔
Cobalt			✔			✔
Copper			✔			✔
Iron			✔	✔		✔
Lead			✔			✔
Magnesium				✔		✔
Manganese			✔			✔
Mercury			✔			✔
Molybdenum			✔			✔
Nickel			✔	✔		✔
Phosphorous						✔
Potassium				✔		✔
Silver						✔
Sodium						✔
Strontium			✔			✔
Thallium						✔
Titanium						✔
Uranium			✔			✔
Vanadium			✔			✔
Zinc			✔			✔
Naphthalene	✔	✔			✔	✔

Step Three: Compare data that exceed baseline concentrations to media-specific regulatory criteria

The next step in the chemical screening process involved comparison of chemicals retained from step two to applicable regulatory criteria. If chemical concentrations for the application case exceeded regulatory criteria, they were carried forward to step four of the chemical screening process. In addition, if regulatory criteria were not available for a chemical, it was retained and carried forward to step four of the chemical screening process. The specific comparisons for each media are presented below.

Water Quality

Water quality criteria were used to screen both surface water and snow data. The Health Canada Guidelines for Drinking Water Quality (Health Canada 2001) were used. Since Health Canada (2001) does not have guidelines for a number of metals, a secondary screening approach was used in this step. Metals that exceeded drinking water quality guidelines were compared with U.S. EPA Region III risk-based concentrations for drinking water (RBCs; U.S. EPA 2001). These concentrations are peer-reviewed screening concentrations that are derived using a risk-based (*i.e.*, for protection of human health) approach, like the approach used in this assessment. The approach used by the U.S. EPA assumes that all drinking water would come from one source (*e.g.*, Snap Lake). Therefore, using these risk-based criteria is a conservative screening approach, since water from Snap Lake or snow would only be consumed at most, for 30 days per year.

Application case and post-closure case water and snow concentrations are compared to regulatory criteria in Tables XI.1-29 through XI.1-34. None of the chemical concentrations predicted in Snap Lake (*i.e.*, application case) or the north lake (*i.e.*, post-closure case) water exceeded the drinking water guidelines or the U.S. EPA RBCs. Therefore, chemicals in water were not carried forward to the next chemical screening step. A few substances in snow (*i.e.*, calcium, magnesium, potassium) were carried forward to the next chemical screening step, since no guidelines or RBCs were available for comparison.

Table XI.1-29
Snap Lake: Comparison of Predicted Concentrations of Metals in Snap Lake for the Application Case with Drinking Water Quality Guidelines

Chemical	Health Canada Drinking Water Quality Guideline [1] (mg/L)	Application Case Concentration in Mine Water Discharge to Snap Lake (mg/L)
Aluminum	0.1	0.14
Arsenic	0.025	0.001
Barium	1.0	0.3
Cadmium	0.005	0.00007
Chromium	0.05	0.0075
Cobalt	-	0.0006
Copper	≤1.0[2]	0.0031
Iron	0.3[3]	0.45
Lead	0.010	0.00073
Manganese	≤0.05[2]	0.03
Mercury	0.001	0.00008
Molybdenum	-	0.0005
Nickel	-	0.014
Strontium	-	1.5
Uranium	0.02	0.0007
Vanadium	-	0.002
Zinc	≤5[2]	0.01

Notes: [1] Health Canada 2001.
[2] Guideline suggests that the parameter should be less than or equal to the criteria due to non-health related endpoints.
[3] Guideline is based on an aesthetic objective.
Note: Shaded cell indicates that the metal was evaluated further because criteria were exceeded or no criteria are available; mg/L = milligrams per litre.

Table XI.1-30
Snap Lake: Comparison of Predicted Concentrations of Metals in Snap Lake for the Application Case with Risk-Based Concentrations

Chemical	U.S. EPA Region III Risk-Based Concentrations [1] (mg/L)	Application Case Concentration in Mine Water Discharge to Snap Lake (mg/L)
Aluminum	37	0.14
Iron	22	0.45
Molybdenum	0.18	0.0005
Nickel	0.73	0.014
Strontium	22	1.5
Vanadium	0.26	0.002

Notes: [1] U.S. EPA 2001.
mg/L = milligrams per litre.

Table XI.1-31
Snow: Comparison of Predicted Concentrations of Metals in Snow for the Application Case with Drinking Water Quality Guidelines

Metal	Health Canada Drinking Water Quality Guideline[1] (mg/L)	Local Study Area Mean Snow Concentration (mg/L	Regional Study Area Mean Snow Concentration (mg/L)
Aluminum	0.1	1.1	0.0116
Antimony	0.006	0.001	0.00004
Arsenic	0.025	0.0002	0.00003
Barium	1.0	0.1	0.001
Calcium	-	1.4	0.2
Chromium	0.05	0.100	0.1000
Iron	0.3[2]	2.5	0.0117
Magnesium	-	3.2	0.0346
Nickel	-	0.046	0.0004
Potassium	-	0.4	0.0332

Notes: [1] Health Canada 2001.
[2] Guideline is based on an aesthetic objective.
Note: Shaded cells indicate that the metals were evaluated further because no criteria are available or because they exceeded criteria; mg/L = milligrams per litre.

Table XI.1-32
Snow: Comparison of Predicted Concentrations of Metals in Snow for the Application Case with Risk-Based Concentrations

Metal	U.S. EPA Region III Risk-Based Concentrations [1] (mg/L)	Local Study Area Mean Snow Concentration (mg/L	Regional Study Area Mean Snow Concentration (mg/L)
Aluminum	37	1.1	0.0116
Calcium	-	1.4	0.2
Iron	22	2.5	0.0117
Magnesium	-	3.2	0.0346
Nickel	0.7	0.046	0.0004
Potassium	-	0.4	0.0332

Notes: [1] U.S. EPA 2001
Shaded cells indicate that the metals were evaluated further because no criteria are available; mg/L = milligrams per litre.

Table XI.1-33
The North Lake: Comparison of Predicted Concentrations of Metals in the North Lake for the Post-Closure Case with Water Quality Guidelines for the Protection Drinking Water

Chemical	Health Canada Drinking Water Quality Guideline [1] (mg/L)	Post-Closure Case Concentration in the North Lake (mg/L)
Aluminum	0.1	0.040
Barium	1.0	0.020
Beryllium	-	0.0002
Chromium	0.05	0.013
Iron	≤0.3[2]	0.029
Manganese	≤0.05[2]	0.0033
Molybdenum	-	0.003
Strontium	-	0.20
Titanium	-	0.0006
Vanadium	-	0.0003

Notes: [1] Health Canada 2001
[2] Guideline suggests that the parameter should be less than or equal to the criteria due to non-health related endpoints
Shaded cell indicates that the metal was evaluated further because no criteria are available; mg/L = milligrams per litre.

Table XI.1-34
The North Lake: Comparison of Predicted Concentrations of Metals in the North Lake for the Post-Closure Case with Risk-Based Concentrations

Chemical	U.S. EPA Region III Risk-Based Concentrations [1] (mg/L)	Post-Closure Case Concentration in the North Lake (mg/L)
Beryllium	0.073	0.0002
Molybdenum	0.018	0.003
Strontium	22	0.20
Titanium	15	0.0006
Vanadium	0.26	0.0003

Notes: [1] U.S. EPA 2001.
mg/L = milligrams per litre.

Soil

Only naphthalene was retained from step two of the chemical screening process for soil. Therefore, the Canadian Soil Quality Guidelines for Parkland/Recreational Uses (CCME 1999) for naphthalene were used to screen naphthalene concentrations in soil for the application case. The parkland/recreational use criteria were considered to be applicable to a hunting trip scenario.

Naphthalene concentrations in soil are compared to regulatory criteria in Table XI.1-35 (shaded cells indicate exceedances of the criteria in soil). Since the predicted naphthalene concentration in the LSA for the application case exceeded the criterion, it was carried forward to the next step in the chemical screening process.

Table XI.1-35
Soil: Comparison of Predicted Concentrations of Metals and Polycyclic Aromatic Hydrocarbons in Soil for the Application Case with Soil Quality Guidelines for the Parkland and Recreational Land Use

Chemical	Canadian Council of Ministers of the Environment Parkland and Recreational Land Use Guideline [1] (mg/kg)	Local Study Area and Regional Study Area Baseline Mean Concentration (mg/kg)	Local Study Area Application Average Concentration (mg/kg)	Regional Study Area Application Average Concentration (mg/kg)
Polycyclic Aromatic Hydrocarbons				
Naphthalene	0.6	0.07	1.14	0.12

Notes: [1] CCME 1999.
Shaded cells indicate that the metals were evaluated further because predicted concentrations exceed the criterion; mg/kg = milligrams per kilogram.

Traditional Food – Plants

The only chemical in the application case that exceeded the baseline case was naphthalene. There are no human health criteria for naphthalene concentration in plants. Therefore, naphthalene was carried forward to the next step in the chemical screening process for traditional plants.

Traditional Food - Meat

There are no chemical criteria for human health and meat consumption. The only chemical in the application case that exceeded the baseline case (since it was not measured) was naphthalene. Therefore, naphthalene was carried forward to the next step in the chemical screening process.

Fish tissue concentrations were predicted for fish exposed to metals in the north lake during the post-closure case and are presented in Table XI-36. Fish tissue metals concentrations were compared with risk-based concentrations for fish consumption, since there are no regulatory guidelines for these metals. Predicted concentrations were less than risk-based concentrations for all metals. Therefore, fish ingestion was not evaluated further in the impact assessment.

Table XI.1-36
Comparison of Predicted Concentrations of Metals in the Fish for the Post-Closure Case with Risk-Based Concentrations

Chemical	Post-Closure Case Concentration in Fish from the North Lake (mg/kg)	U.S. EPA Region III Risk-Based Concentrations[1] (mg/kg)
Aluminum	40.0	1400
Barium	1.7	95
Beryllium	0.4	2.7
Chromium	2.4	2000
Manganese	1.3	27
Molybdenum	3.3	6.8
Strontium	34.8	810
Vanadium	0.5	9.5

Notes: [1] U.S. EPA 2001.
mg/kg = milligrams per kilogram.

Air

Annual average airborne chemical concentrations are the most relevant for evaluating the potential for chronic human health risks, since these values represent the long-term average concentrations people may be exposed to on a regular basis within the LSA and RSA. Short-term chemical concentrations such as a one hour or one day excursion are relatively rare and not predictive of actual exposures people are likely to incur throughout the year. Thus, annual average chemical concentrations were evaluated for all airborne chemicals (with the exception of $PM_{2.5}$, where the Canada Wide Standard is based on 24-hour exposures).

Annual average air concentrations of metals, PAHs, PM_{10}, $PM_{2.5}$, total suspended particulate (TSP), sulphur dioxide ($SO_{2)}$, and nitrogen dioxide ($NO_{2)}$ were estimated for the LSA and RSA in the application case (refer to Section 7.3 for further details on air predictions).

SO_2 and NO_2

Predicted application case concentrations of SO_2 and NO_2 were much less than the NWT ambient air quality guidelines and the federal ambient air quality objectives (FAAQO) (GNWT 1994; Environment Canada 1999) in the LSA and RSA. The maximum annual average SO_2 concentration is 11.1 micrograms per cubic metre ($\mu g/m^3$), compared to the NWT SO_2 standard of 30 $\mu g/m^3$. While the predicted maximum annual average concentration of NO_2 (117.4 $\mu g/m^3$) is greater than FAAQO of 100 $\mu g/m^3$, the maximum occurs on-site in a small area (Section 7.3). The maximum NO_2 concentration in the remaining areas is 26.2 $\mu g/m^3$, which is much less than the FAAQO. For these reasons, SO_2 and NO_2 were not evaluated further in the human health impact assessment.

Particulate Matter

Baseline TSP concentrations were not available; however since there are no other industries within the RSA or LSA, the Snap Lake Diamond Project is the only source of TSP within the RSA and LSA. TSP predictions are detailed in Section 7.3. In summary, the annual maximum TSP concentration for the application case is predicted to be 17.9 $\mu g/m^3$ within the RSA, which is less than the NWT TSP standard of 60 $\mu g/m^3$. Within the LSA, the annual maximum TSP concentration for the application case is predicted to be 101.7 $\mu g/m^3$, which exceeds the NWT TSP standard. It is expected that the exceedance of the NWT standard would only occur once per year. Since annual average TSP concentrations would be less than the NWT standard, TSP was not evaluated further in the human health impact assessment.

Metals and Polycyclic Aromatic Hydrocarbons

Predicted concentrations of metals and PAHs (associated with particulate matter) in air were compared to the U.S. EPA Region III Risk-Based Criteria (U.S. EPA 2001; Tables XI.1-37 and XI.1-38). None of the application case air concentrations exceeded the RBCs. A few substances for which RBCs are unavailable (*i.e.*, calcium, magnesium, potassium) were carried forward to the next screening step.

Table XI.1-37
Application Case Predicted Metal Concentrations in Air Compared with Risk-Based Concentrations

Metals	U. S. EPA Region III Risk-Based Concentrations [1] (µg/m³)	Concentration (µg/m³)	
		Regional Study Area	Local Study Area
Aluminum	3.7	0.0001	0.005
Antimony	1.5	0.000000	0.000000
Arsenic	0.00041	0.000000	0.000002
Barium	0.51	0.000008	0.0004
Boron	21	0.000000	0.00002
Cadmium	0.001	0.000000	0.000001
Calcium	-	0.0003	0.02
Chromium (III)	5500	0.000004	0.0002
Cobalt	0.018	0.000000	0.00002
Copper	150	0.000001	0.00002
Iron	2200	0.0003	0.02
Lead	8	0.000000	0.000004
Magnesium	-	0.0008	0.04
Manganese	0.52	0.00001	0.0005
Mercury	0.31	0.000000	0.000000
Molybdenum	18	0.000000	0.000005
Nickel	73	0.000006	0.0003
Phosphorus	0.073	0.00001	0.0007
Potassium	-	0.00004	0.002
Silver	18	0.000000	0.000000
Sodium	15	0.000002	0.0001
Strontium	2200	0.000002	0.00008
Thallium	0.26	0.000000	0.000001
Titanium	31	0.000006	0.0003
Uranium	11	0.000000	0.000001
Vanadium	26	0.000000	0.00002
Zinc	1100	0.000001	0.00005

Notes: [1] U.S. EPA 2001.
mg/m3 = micrograms per cubic metre.

Table XI.1-38
Application Case Predicted Polycyclic Aromatic Hydrocarbons Concentrations in Air Compared with Risk-Based Concentrations

Polycyclic Aromatic Hydrocarbons	U. S. EPA Region III Risk-Based Concentrations [1] (µg/m³)	Concentration (µg/m³)	
		Regional Study Area	Local Study Area
Acenaphthene	220	0.0007	0.01
Acenaphylene	220[2]	0.001	0.03
Anthracene	1100	0.0002	0.004
1,2-Benzathracene	0.02	0.00000	0.00007
Benzo(b & j)fiuoranthene	0.086	0.00002	0.0005
Benzo(k)fluoranthene	0.086	0.00002	0.0004
Benzo(a)fluorene	0.002[3]	0.00005	0.0009
Benzo(b)fluorene	0.002[3]	0.00000	0.00004
Benzo(g, h, i)perylene	0.2	0.00004	0.0009
Benzo(a)pyrene	0.002	0.00002	0.0004
Benzo(e)pyrene	0.2	0.00000	0.00009
Camphene	3.3[4]	0.00001	0.00011
Carbazole	0.31	0.00000	0.00006
1 –Chloronaphthalene	290	0.00000	0.00006
2-Chloronaphthalene	290	0.00000	0.00008
Chrysene	0.86	0.0001	0.003
Dibenz(a, j)acridine	3.3[4]	0.00000	0.00007
Dibenz(a, h)acridine	3.3[4]	0.00000	0.00005
Dibenz(a, h) anthracene	0.002	0.00005	0.001
Dibenzothiophene	3.3[4]	0.0003	0.007
7,12-dimethylbenz(a)anthracene	0.02	0.00000	0.00005
1, 6-Dinitropyrene	0.002	0.00000	0.00005
1, 8-Dinitropyrene	0.002	0.00000	0.00005
Fluoranthene	150	0.0005	0.01
Fluorene	150	0.002	0.04
Indeno(l, 2, 3-cd)pyrene	0.0086	0.00000	0.00008
Indole	3.3[4]	0.00001	0.0001
1 –Methylnaphthalene	3.3	0.0001	0.002
2-Methylnaphthalene	3.3	0.0001	0.002
Naphthalene	3.3	0.02	0.4
Nitro-pyrene	0.02	0.00000	0.00008
Perylene	0.002	0.00000	0.00005
Phenanthrene	150	0.005	0.1
Pyrene	110	0.0004	0.008
Retene	3.3[4]	0.00003	0.0007
Nitrobenzanthrone	0.002[3]	0.00000	0.00000

Notes: [1] U.S. EPA 2001
[2] Based on acenaphthene.
[3] No RBC available, but a possible carcinogen. Conservatively applied the RBC for the most toxic carcinogenic PAH, benzo[a]pyrene.
[4] No RBC available, but not a carcinogen. Conservatively applied the lowest RBC non-carcinogenic PAHs, naphthalene.
mg/m3 = micrograms per cubic metre.

Step Four : Evaluation of Required Nutrients or Non-toxic Chemicals

Certain chemicals may be eliminated from further consideration based on their importance as a dietary component or essential nutrient, or based on a general lack of toxic effects. Calcium, magnesium and potassium can be eliminated from the list of chemicals for further evaluation due to dietary requirements.

Calcium

Calcium is an essential mineral for developing and maintaining healthy bones and teeth, assisting in blood clotting, muscle contraction, nerve transmission and for maintaining immune function. Intakes of amounts of 2,500 mg are safe for most people. Concentrations measured and predicted in snow are much less than 2,500 mg and would not cause toxicity (Groff *et al.* 1995). Therefore, calcium was not evaluated in the impact assessment.

Magnesium

Magnesium is an essential mineral and is important in activating enzymatic reactions, in glucose metabolism, in production of cellular energy, in the synthesis of protein and nucleic acid, and the regulation of cellular calcium flow (U.S. FDA 1999). An excessive intake of magnesium is unlikely to cause toxicity (Groff *et al.* 1995). Therefore, magnesium was not evaluated in the impact assessment.

Potassium

Potassium is an essential mineral that is important in the regulation of heartbeat, fluid balance maintenance, muscle contraction, and energy production (U.S. FDA 1999). It is considered to be almost impossible to ingest quantities of potassium high enough to cause toxicity (Groff *et al.* 1995). Therefore, potassium was not evaluated in the impact assessment.

Final Chemical List

Only naphthalene remained on the chemical list for the human health risk assessment (Table XI.1-39). No chemicals exceeded baseline or applicable criteria in surface water. Although naphthalene did not consistently screen on in every media evaluated, the naphthalene concentrations in all relevant media were used in the risk assessment to determine total exposures for the hunter scenario.

Table XI.1-39
Final List of Chemicals Evaluated in the Human Health Risk Assessment

Chemical	Traditional Food - Caribou Meat	Traditional Food - Plants	Soil
Naphthalene	✔	✔	✔

5.1.4 Exposure Pathway Screening

The objective of the exposure pathway screening process is to identify potential routes by which people could be exposed to chemicals and the relative significance of these pathways to total exposure. A chemical represents a potential health risk only if it can reach receptors through an exposure pathway at a concentration that could potentially lead to adverse effects. If there is no pathway for a chemical to reach a receptor, then there cannot be a risk, regardless of the chemical concentration. Figure XI.1-4 presents the potential exposure pathways for the human health assessment. Each of these exposure pathways is evaluated below.

Ingestion of Surface Water

It is possible that people may drink from surface waterbodies within the RSA and LSA while hunting or fishing. Water quality from Snap Lake was considered to be the worst case scenario for surface water quality, compared to other regional lakes, due to its proximity to the Snap Lake Diamond Project. However, concentrations of metals from Snap Lake and the north lake are less than regulatory guidelines and risk-based concentrations. PAHs, including naphthalene, were not predicted to be present in waterbodies near the Snap Lake Diamond Project. Therefore, consumption of water was not evaluated for hunters in the application or post-closure cases.

Community members would not use Snap Lake or the north lake as a source for daily consumption. Therefore, this pathway was not evaluated for community residents for the application or post-closure cases.

Direct contact with Surface Water

People would be unlikely to bathe in lakes and streams within the LSA and RSA. If people did bathe in these waters, it is expected that they would not receive significant doses through this route relative to other routes, such as direct ingestion of water.

Therefore, this pathway was not evaluated in the impact assessment for the application or post-closure cases.

Ingestion of Snow

It is possible that people may be hunting and fishing during winter months and may consume snow as a source of drinking water. Dust deposition on snow may result in increased concentrations of chemicals in melted drinking water. Therefore, this pathway was evaluated for hunters in the impact assessment for the application case. Air emissions and consequently, deposition to snow, will cease after closure. Therefore, this pathway was not evaluated for the post-closure case.

Community members would not use snow in the LSA and RSA as a source for daily consumption. Therefore, this pathway was not evaluated for community residents in the application or post-closure cases.

Direct contact with Processed Kimberlite

People should not have direct skin contact with processed kimberlite while hunting or fishing. Therefore, this pathway was not evaluated in the impact assessment for the application or post-closure cases.

Ingestion of Fish

People may also eat fish that they catch within the RSA and LSA. Fish may accumulate metals. Non-employees will be allowed to fish in Snap Lake. However, it is unlikely that people would fish in Snap Lake when the Project is in operation due to the noise associated with operations. Therefore, the worst-case scenario would be fishing from the north lake during post-closure, since water quality in the post-closure case is predicted to be poorer than in Snap Lake during operation. However, predicted fish tissue metal concentrations are less than risk-based concentrations and naphthalene is not predicted to be present in water bodies near the Snap Lake Diamond Project. Therefore, this pathway was not evaluated for the application or post-closure cases.

Inhalation of Dust in Air

While hunting and fishing in the LSA and RSA, people may be exposed to airborne emissions from the Snap Lake Diamond Project. Therefore, inhalation of airborne fugitive dust was evaluated as an exposure pathway for hunters in the impact assessment for the application case. Air emissions will cease post-closure. Therefore, this pathway was not evaluated for the post-closure case.

Community members would not be directly exposed to dust emissions from the project because the nearest community is beyond the area of dust transport. Therefore, this pathway was not evaluated for community residents for the application or post-closure cases.

Ingestion of Plants

People may also consume plants in the LSA and RSA while hunting and fishing. Therefore, this exposure pathway was evaluated for hunters in the impact assessment for the application case. However, it is very unlikely that people would transport vegetation back to the communities since there are closer sources of vegetation (Lutsel K'e Dene First Nation 2001). Therefore, this pathway was not evaluated for community residents. Air emissions will cease post-closure thereby no longer affecting plant quality. This pathway was not evaluated in the post-closure case because chemical emissions from the Snap Lake Diamond Project will cease after closure.

Ingestion of Soil

People may inadvertently ingest soil in the LSA and RSA while hunting and fishing via hand-to-mouth contact. Therefore, this exposure pathway was evaluated for hunters in the application case. Air emissions will cease post-closure and will no longer affecting soil quality.

Community members would not have daily contact with this soil. Therefore, this pathway was not evaluated for community residents. This pathway was not evaluated in the post-closure case because chemical emissions from the Snap Lake Diamond Project will cease after closure.

Ingestion of Animals

People will consume animals harvested from the LSA and RSA. The most important source of meat is caribou (Schaefer and Steckle 1980; Section 6.3). Therefore, this exposure pathway was evaluated for hunters and community residents for the application case. This pathway was not evaluated in the post-closure case because chemical emissions from the Snap Lake Diamond Project will cease after closure.

5.2 Exposure Assessment

5.2.1 Spatial and Temporal Boundaries

The human health exposure assessment uses the timeline for the application case of the Snap Lake Diamond Project (22 years). It was assumed that a hunter/trapper would spend 30 days per year in the LSA. This is a conservative assumption because it is unlikely that an individual would be hunting/trapping within 500 m of the mine footprint (*i.e.*, LSA area). It is also unlikely that an individual would be hunting/trapping in the LSA for 30 days per year since the potential hunting areas in the NWT are vast and would not be restricted to this small area. Since chemical concentrations are higher in the LSA than the RSA, assuming a hunter spends 30 days within the LSA is considered to be the worst-case possible exposure scenario. Therefore, if risks are not predicted for this scenario, risks also would not be predicted for other scenarios (*e.g.*, less time in the LSA, or time in the RSA).

5.2.2 Exposure Estimate Equations

Exposure estimate equations used for the human health exposure assessments are presented in Table XI.1-40.

Equations presented in Section 4.1.2 to predict vegetation and meat concentrations of metals and PAHs were also used for the human health assessment.

5.2.3 Human Health Receptor Parameters

Details on the body weights, food ingestion rates, water ingestion rates, soil ingestion rates and air inhalation rates for humans are presented in Table XI.1-41.

Table XI.1-40
Exposure Equations

Pathway	Equation and Equation Parameters
Water Ingestion (surface water and snow)	$EDI_{water} = \frac{IR \times BA \times C_{water} \times EF}{BW \times AT}$
	EDI_{water} = exposure due to ingestion of water (mg chemical/kg body weight-. day) IR = ingestion rate (L/d) BA = oral bioavailability of chemical (chemical-specific, unitless) C_{water} =chemical concentration in water or snow (mg/L) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year; 365 days/year)
Air Inhalation	$EDI_{air} = \frac{IR \times BA \times C_{air} \times EF}{BW \times AT}$
	EDI_{air} = exposure due to inhalation of air (mg chemical/kg body weight - day) IR = inhalation rate (m^3/d) BA = oral bioavailability of chemical (chemical-specific, unitless) C_{air} = chemical concentration in air (mg/m^3) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year; 365 days/year)
Soil Ingestion	$EDI_{soil} = \frac{IR \times BA \times C_{soil} \times EF}{BW \times AT}$
	EDI_{soil} = exposure due to ingestion of soil (mg chemical/kg body weight - day) IR = ingestion rate (kg/d) BA = oral bioavailability of chemical (chemical-specific, unitless) C_{soil} = chemical concentration in soil (mg/kg) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year; 365 days/year)
Vegetation Ingestion	$EDI_{vegetation} = \frac{IR \times BA \times C_{vegetation} \times EF}{BW \times AT}$
	$EDI_{vegetation}$ = exposure due to ingestion of vegetation other than lichen (mg chemical/kg body weight - day) IR = ingestion rate (kg/d) BA = oral bioavailability of chemical (chemical-specific, unitless) C_{lichen} = chemical concentration in soil (mg/kg) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year; 365 days/year)
Food Ingestion (*i.e.*, caribou)	$EDI_{food} = \frac{IR \times BA \times C_{food} \times EF}{BW \times AT}$
	EDI_{food} = exposure due to ingestion of prey (mg chemical/kg body weight - day) IR = ingestion rate (kg/d) BA = oral bioavailability of chemical (chemical-specific, unitless) C_{food} = chemical concentration in soil (mg/kg) EF = exposure frequency (days/year) BW = receptor body weight (kg) AT = averaging time (total number of days per year; 365 days/year)

Note: mg/kg = milligrams per kilogram; L/d = litres per day; mg/L = milligrams per litre; kg = kilogram; m^3/d = cubic metres per day; mg/m^3 = milligrams per cubic metre; kg/d = kilograms per day.

Table XI.1-41
Exposure Parameters Used in the Human Health Risk Assessment

Receptor	Weight (kg)[1]	Water/Snow Ingestion Rate (L/d)[1]	Soil Ingestion Rate (mg/d)[1]	Inhalation Rate (m^3/d)[1]	Meat Ingestion Rate (g/d)[2]	Vegetation Ingestion Rate (g/d)[2]
Toddler	13	0.8	80	5	84	67
Child	27	0.9	20	12	126	98
Adult	70	1.5	20	23	283	143

Notes: [1] CCME 1996.
[2] Richardson 1997.

Note: kg = kilogram; L/d = litres per day; mg/d = milligrams per day; m^3/d = cubic metres per day; g/d = grams per day.

5.3 Toxicity Assessment

Naphthalene

Oral RfD

An oral RfD for naphthalene of 0.02 mg/kg-day, established by the U.S. EPA (IRIS 2001), was used for this assessment. The U.S. EPA based the RfD on a subchronic 90-day study by Battelle's Columbus Laboratories (BCL) for the National Toxicology Program (NTP). The sub-chronic study involved administration of naphthalene (>99% pure in corn oil) by gavage at dose levels of 0, 25, 50, 100, 200 or 400 mg/kg, for 5 days per week, for 13 weeks (IRIS 2001). A NOAEL of 100 mg/kg-day (71 mg/kg-day duration-adjusted) was identified based on a greater than 10% decrease in terminal body weight compared to control. A LOAEL of 200 mg/kg-day was identified based on decreased body weight. To derive the oral RfD of 0.02 mg/kg-day, an uncertainty factor of 3000 was applied to the NOAEL (10 for interspecies extrapolation, 10 for intraspecies extrapolation, 10 to extrapolate from subchronic to chronic exposure and 3 for database deficiencies (IRIS 2001).

Inhalation Reference Dose

An inhalation RfC for naphthalene of 0.003 milligrams per cubic metre ($mg/m^{3)}$, established by the U.S. EPA (IRIS 2001), was used for this assessment. The U.S. EPA based the inhalation RfC on a chronic 103-week study by the NTP. The chronic study involved exposing mice (75/sex/group) at target concentrations of 0, 10 and 30 ppm (0, 52, 157 mg/m^3) for 6 hours/day, 5 days/week, for 103 weeks (NTP 1992). The chronic inhalation RfC is based on nasal effects such as inflammation, metaplasia of the olfactory epithelium, and hyperplasia of the respiratory epithelium, with effects slightly more severe in the high concentration group. The NTP study identified an adjusted LOAEL of 9.3 mg/m^3 for nasal effects (hyperplasia in respiratory epithelium and metaplasia in olfactory epithelium) was divided by an uncertainty factor of 3000 (10 for interspecies extrapolation, 10 for intraspecies extrapolation, 10 to extrapolate from a LOAEL to a NOAEL, and three for database deficiencies; IRIS 2001).

5.4 Risk Characterization

Tables XI.1-42 present the ERs for people hunting within the LSA. These ERs represent exposure to naphthalene from air inhalation, plant ingestion, soil ingestion and meat ingestion. For children and toddlers, the main source of exposure was soil ingestion, while for adults the main source of exposure was inhalation of dust. Since all ERs are less than one, no risks are predicted.

Table XI.1-42
Exposure Ratios for the Baseline and Application Cases for People Hunting within the Local Study Area

Chemical	Baseline	Application
Toddler		
Naphthalene	0.002	0.3
Child		
Naphthalene	0.0008	0.06
Adult		
Naphthalene	0.00003	0.03

Table XI-43 presents the ERs for community residents that consume caribou meat that has been hunted from the LSA. Predicted ERs for the application case are substantially below one; therefore, no health risks are predicted.

Table XI.1-43
Exposure Ratios for the Baseline and Application Cases for Community Residents

Chemical	Baseline[1]	Application
Toddler		
Naphthalene	-	0.0003
Child		
Naphthalene	-	0.0003
Adult		
Naphthalene	-	0.0002

Notes: [1] Baseline naphthalene concentrations were not measured; therefore, baseline caribou meat concentrations could not be calculated.

6.0 REFERENCES FOR ENVIRONMENTAL HEALTH APPENDIX

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7.0 UNITS AND ACRONYMS

UNITS

g/d	grams per day
g/ha/yr	grams per hectare per year
kg	kilogram
kg/d	kilogram per day
kg/ha/yr	kilograms per hectare per year
kg/m^3	kilograms per cubic metre
ha/m^2	hectare per cubic metre
L/d	litres per day
m	metres
m^3/d	cubic metres per day
mg/d	micrograms per day
mg/g	milligrams per gram
mg/kg	milligrams per kilogram
mg/kg/d	milligrams per kilograms per day
mg/L	milligrams per litre
mg/m^3	milligrams per cubic metre
µg/m^3	microgram per cubic metre

ACRONYMS

AEP	advanced exploration program
BCL	Battelle's Columbus Laboratories
B.C. MOELP	British Columbia Ministry of Environment, Lands and Parks
CCME	Canadian Council of Ministers of the Environment
CEA	cumulative effects assessment
COSEWIC	Committee on the Status of the Endangered Wildlife in Canada
De Beers	De Beers Canada Mining Inc.
EA	environmental assessment
ER	exposure ratio
FAAQO	federal ambient air quality objectives
GNWT	Government of the Northwest Territories
IRIS	integrated risk information system
LOAEL	lowest observable adverse effect level
LSA	local study area
$N0_2$	nitrogen dioxide
NOEAL	no observed adverse effect level
NTP	National Toxicology Program
NWT	Northwest Territories
PAH	polycyclic aromatic hydrocarbon

RfD	reference dose
RfC	reference concentration
RSA	regional study area
RWED	Resources, Wildlife and Economic Development
$S0_2$	sulphur dioxide
TSP	total suspended particulate
U.S. EPA	United States Environmental Protection Agency
VEC	valued ecosystem components
WHO	World Health Organization