ATTACHMENT A

WILDLIFE RISK ASSESSMENT

DEVELOPER'S ASSESSMENT REPORT

December 2011

NICO COBALT-GOLD-BISMUTH-COPPER PROJECT

Wildlife Health Risk Assessment

Submitted to:
Mackenzie Valley Review Board
200 Scotia Centre
PO Box 938
Yellowknife, NWT, X1A 2N7
Canada

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Golder Associates

FORTUNE MINERALS LIMITED

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1.0 INTRODUCTION

1.1 Context

Fortune Minerals Limited (Fortune) proposes to develop a new underground and open pit cobalt, gold, copper, and bismuth mine and processing plant, hereinafter referred to as the NICO Cobalt-Gold-Copper-Bismuth Project (NICO Project). This report provides a detailed description of the Wildlife Health Risk Assessment (WHRA) undertaken for the NICO Project. The WHRA provides an assessment of the potential health effects to wildlife that may occur as a result of changes to the environment due to predicted discharges from the NICO Project.

1.2 Purpose and Scope

The purpose of the WHRA was to:

- satisfy the requirements of the Terms of Reference (TOR) issued by the Mackenzie Valley Review Board (MVRB 2009); and
- address the concerns raised by the Tłįchǫ Government and other citizens regarding permitting of the NICO Project.

The MVRB approach to a TOR document includes the identification of Key Lines of Inquiry (KLOI), which are defined as the "areas of greatest concern that require the most attention during the environmental assessment and the most rigorous analysis and detail in the Developer's Assessment Report (DAR)" (MVRB 2009). Additional detail regarding the MVRB approach to environmental assessment is provided in the DAR (Fortune 2011). Of the 3 KLOI identified in the TOR for the NICO Project, all 3 are relevant to wildlife health and were addressed through the various components of the WHRA. These include Water Quality, Closure and Reclamation, and Caribou and Caribou Habitat. The assessment and measurement endpoints for wildlife for these KLOI were identified in the DAR (Section 15) and are summarized in Table 1.2-1. In the DAR, assessment endpoints are defined as key properties of wildlife that should be protected for their use by future human generations, while measurement endpoints are defined as quantifiable (i.e., measurable) expressions of changes to assessment endpoints.

Table 1.2-1: Assessment and Measurement Endpoints for the Key Lines of Inquiry that are Relevant for the Wildlife Health Risk Assessment

KLOI	Assessment Endpoints	Measurement Endpoints	Section in DAR[a]
KLOI: Water Quality	• Persistence of wildlife populations • Continued opportunity for traditional and non-traditional use of wildlife	Survival and reproduction	Section 7.0
KLOI: Caribou and Caribou Habitat	• Persistence of caribou populations • Continued opportunity for traditional and non-traditional use of caribou	Survival and reproduction of caribou	Section 8.0
KLOI: Closure and Reclamation	• Protection of surface water quality for terrestrial ecosystems • Persistence of wildlife populations • Continued opportunity for traditional and non-traditional use of wildlife	Survival and reproduction	Section 9.0

[a] Developer's Assessment Report (Fortune 2011).

Of the concerns raised by the Tłı̨chǫ Government and other citizens with respect to the NICO Project, 5 were not captured within the KLOI and are potentially relevant to wildlife health. These include the following:

i) Hislop Lake and the Marian River are important traditional and recreational areas.

ii) Potential cumulative effects due to the old Rayrock mine and Colomac mine.

iii) Concerns regarding the use of chemicals in the processing of ore (specifically cyanide).

iv) Concerns regarding the presence of the waste rock piles and the safety of the Co-Disposal Facility (CDF).

v) Concerns regarding the potential for wildlife contamination.

To satisfy the requirements of the TOR and to address the concerns raised by the Tłı̨chǫ Government and other citizens, the WHRA focussed on the following:

- assessment of the potential risks to wildlife due to emissions from the NICO Project, including those KLOI identified in the TOR as they pertain to wildlife health; and
- addressing the concerns raised by the Tłı̨chǫ Government and other citizens as they pertain to wildlife health. Specifically, Hislop Lake and the Marian River were assessed in the WHRA as potential receptor locations, the potential for cumulative effects due to neighbouring mines was assessed in the WHRA, the presence of the CDF was evaluated with respect to wildlife health, and an assessment of the potential for chemicals such as arsenic to adversely affect wildlife health was evaluated in the WHRA. Cyanidation was not included in the Project Description (Section 1.3) and as such was not considered further in the WHRA.

In mining projects, potential impacts can only occur where there is a direct link between project activity and the environment. Therefore, the WHRA focused on those aspects of the NICO Project that could result in Project-related discharges to the environment, thereby potentially impacting wildlife where there is a complete exposure pathway between a source and a receptor. To facilitate an understanding of the NICO Project activities that could result in potential impacts to wildlife, a brief description of the NICO Project, and the study areas used to analyze and assess effects to wildlife is provided in the next section.

1.3 Project Description

1.3.1 Project Location

The NICO Project is located approximately 160 kilometres (km) northwest of Yellowknife, Northwest Territories (NWT) within the Marian River drainage basin, approximately 10 km east of Hislop Lake at a latitude of 63°33' North, and a longitude of 116°45' West (Figure 1.2-1 of the DAR).

The NICO Project site has rugged topography. The site topography is illustrated in Figure 1.2-4 of the DAR. Absolute elevations at the NICO Project site range from 150 to 350 meters above sea level (masl). The ore body is located on the northern slope of a bowl-shaped depression referred to as the "Bowl Zone". The south end of the proposed mine is located on a ridge of exposed bedrock, which slopes down towards the north end of the proposed mine in the Grid Stream depression.

With the exception of Fortune's leases, all of the land surrounding the mine is within the Tłı̨chǫ settlement lands owned and managed as fee-simple lands by the Tłı̨chǫ Dèts'ǫ Kàowo as per the Tłı̨chǫ Agreement (Figure 1.2-2 of the DAR). The Tłı̨chǫ lands are within the Wek'èezhìı co-management lands, jointly managed with the

Northwest Territory and Federal Government. Fortune's exploration leases were staked and brought to lease prior to settlement of the Tłįchǫ land claim and as Crown Land are administered by the Federal Government.

Subject to approvals, the plant site will be constructed approximately 500 metres (m) west of Nico Lake, between Nico and Lou lakes.

1.3.2 The Proposed NICO Project

The NICO Project includes development of an underground mine and open pit. The current proposed site development for the NICO Project is shown in Figure 1.2-3 of the DAR. Proposed on-site infrastructure includes the following:

- mine site with open pit and underground operations;
- tailings and mine rock management area (presented as a single CDF);
- Mineral Process Plant (the Plant);
- Effluent Treatment Facility (ETF), with discharge into Peanut Lake through a diffuser;
- Sewage Treatment Plant;
- drainage controls;
- fuel and chemical storage facilities;
- Materials Sorting Facility;
- Landfarm;
- Explosives storage area;
- roads within the mine site and NICO Project Access Road (NPAR) with access to site via the proposed Tłįchǫ Road Route; and
- fresh water intake on Lou Lake.

Primary processing of the ore will be conducted on-site in the Plant, including crushing, grinding, and floatation (consisting of primary and secondary stages) to produce bulk concentrate. The concentrate will then be shipped off-site for final processing. Cyanidation and a cyanide destruction circuit will not be incorporated into the final NICO Project design.

During operation of the mine, the NICO Project will generate mine rock and tailings. The mine rock includes soil and overburden from pre-stripping above the ore body and mine rock from development of the Open Pit. Processing of the ore will result in generation of tailings. Mine rock and tailings will be disposed of in the CDF. At closure, the CDF will be capped.

Several mine activities will generate excess water, including ore processing and pumping from the Open Pit and underground workings. All water that comes into contact with the mine facilities during construction, operations, and closure will be managed. During operations, the CDF will house the water management facilities, the major components of which will include the following:

- Reclaim Pond on the CDF. This pond will be relocated throughout the mine's operating life as the CDF develops;
- 5 Seepage Collection Ponds (SCPs) located downstream of the CDF;
- Surge Pond near the Plant;
- Plant Site Runoff Pond;
- Sewage Treatment Plant (STP);
- ETF;
- Contingency Pond (will be constructed if required) for additional settling or polishing of ETF effluent, or if the site requires additional storage capacity; and
- related water management facilities, including drainage ditches, emergency spillways, pump stations, and the reclaim water pipeline system.

During operations, all water that has been in contact with ore or mine waste will be collected in one of the following: the SCPs, the Open Pit sump, or the Reclaim Pond. Collected water in these ponds/sump will be pumped to the Surge Pond. Water will then be pumped from the Surge Pond either to the Plant for reuse or to the ETF for treatment. Treated effluent from the ETF and STP will be pumped through a diffuser directly into Peanut Lake.

During closure, pumping water out of the Open Pit will cease and the Open Pit will slowly fill with water. The rate of filling will increase by directing CDF runoff (and seepage reporting to SCP No. 4) into the Open Pit by breaching the SCP No. 4 dam. The Project Description assumes that water that accumulates in SCP Nos. 1, 2, 3, and 5, as well as the Surge Pond will be passively treated in Wetland Treatment Systems and then released directly into Nico Lake. Overflow from the Open Pit will be passively treated in Wetland Treatment System No. 4 and released into Peanut Lake. This is subject to demonstrating the technical performance of the Wetland Treatment Systems.

Potential NICO Project activities that could result in emissions to the environment are listed below:

- emission of chemicals to air from fuel combustion sources such as mine equipment and vehicles;
- generation of road dust during transportation of concentrate to off-site processing facilities during operation;
- mining, crushing, and disposal of mine rock and tailings during operation;
- water discharges, including the following:
  - management and discharge of stormwater runoff;
  - discharge of water from the ETF during operation;
  - seepage from the CDF during operation and post-closure; and
  - flooding of the Open Pit during post-closure.

1.4 Study Areas

This section contains a brief description of the study areas used to analyze and assess effects to wildlife with reference to sections and figures within the DAR (Fortune 2011).

1.4.1 General Setting

The NICO Project is approximately 160 km northwest of the city of Yellowknife in the NWT (Figure 1.2-1 of the DAR). The NICO Project is located within the Marian River drainage basin, approximately 10 km east of Hislop Lake at a latitude of 63°33' North and a longitude of 116°45' West, and within the Taiga Shield and Taiga Plains Ecoregions (Ecosystem Classification Group 2007, 2008). The NICO Project spans 2 Level II Ecoregions: Taiga Shield and Taiga Plains.

The NICO Project site is located in the central part of the Tłįchǫ lands, NWT. The Tłįchǫ lands are described as part of the Tłįchǫ Land Claims and Self Government Agreement (the Agreement), negotiated by the Dogrib Treaty 11 Council, the Government of the Northwest Territories (GNWT), and the Government of Canada, and signed in August 2005 (http://www.ainc-inac.gc.ca/ai/mr/nr/j-a2005/2-02586-eng.asp). The current Tłįchǫ lands cover approximately 39 000 square kilometres (km^2), including the subsurface resources (http://www.ainc-inac.gc.ca/ai/mr/nr/j-a2005/2-02586-eng.asp).

There are 4 primary communities within the Tłįchǫ lands, including Behchokǫ̀, Whatì, Gamètì, and Wekweètì. The NICO Project is located approximately 80 km north of Behchokǫ̀, 50 km north of Whatì, and 50 km south of Gamètì. The fourth community, Wekweètì, is located the farthest from the NICO Project, approximately 145 km northeast. The NICO Project is within the traditional land use areas of the Tłįchǫ and the Métis.

1.4.2 Regional and Local Study Areas

A conventional terminology was used: regional study area (RSA) and local study area (LSA). The RSA is selected to capture the larger scale direct and indirect effects from the NICO Project on wildlife (i.e., contains the maximum zone of influence from the NICO Project). The LSA represents the area that may be directly affected by the mine footprint, and that may potentially experience small-scale indirect effects from activities associated with the NICO Project.

These study areas differ depending on the NICO Project disciplines. The study areas for the WHRA were aligned with the study areas identified by the NICO Project disciplines that will predict potential NICO Project-related changes to environmental quality (i.e., air quality, water quality, soil and vegetation chemistry), or that provided information relevant to wildlife receptors. The reader is referred to the relevant sections of the DAR for detailed descriptions of the study areas for the air quality assessment (Section 10.0, Figure 10.1-2 of the DAR), water quality assessment (Section 7.0, Figure 7.1-1 of the DAR), terrain and soils assessment (Section 13.0, Figure 13.1-2 of the DAR), vegetation assessment (Section 14.0, Figure 14.1-2 of the DAR), and wildlife assessment (Section 15.0, Figure 15.1-3 of the DAR).

1.5 Content

This report is generally organized as follows:

- Section 2.0: Risk Assessment Framework and General Approach, describes each component of the risk assessment (RA) framework (problem formulation, exposure assessment, toxicity assessment, risk characterization) and the general approach used in the WHRA.

- Section 3.0: Data Used in the Wildlife Health Risk Assessment, summarizes the data used in support of the WHRA.
- Section 4.0: Wildlife Health Risk Assessment, provides the assessment of the potential health effects to wildlife that may occur as a result of the changes to the environment due to predicted emissions from the NICO Project.
- Section 5.0: Summary of Wildlife Health Results and Conclusions, provides the overall assessment of NICO Project-related effects on wildlife health (including an assessment of the cumulative effects due to foreseeable projects, developments, activities, and natural factors that influence the environment).
- Section 7.0: References, provides the sources of information relied upon in the WHRA.
- Section 8.0: Acronyms and Abbreviations.
- Section 9.0: Glossary.

The following appendices are also included in this report to provide additional detailed information:

- Appendix A: Pathways Analysis Table
- Appendix B: Soil, Water, and Sediment Screening Tables
- Appendix C: Toxicity Reference Values for Mammals and Birds

2.0 RISK ASSESSMENT FRAMEWORK AND GENERAL APPROACH

2.1 Risk Assessment Framework

Risk assessment is a scientific tool used to characterize the nature and magnitude of potential risks, if any, associated with the exposure of receptors (e.g., wildlife) to chemicals. For there to be a potential risk, the following 3 conditions must be met:

- a chemical must be present at levels that could be harmful;
- a receptor must be present; and
- there must be an exposure pathway by which the receptor can come into contact with the chemical.

These 3 conditions are illustrated in Figure 2.1-1, where risk is anticipated to occur when the 3 necessary conditions are met.

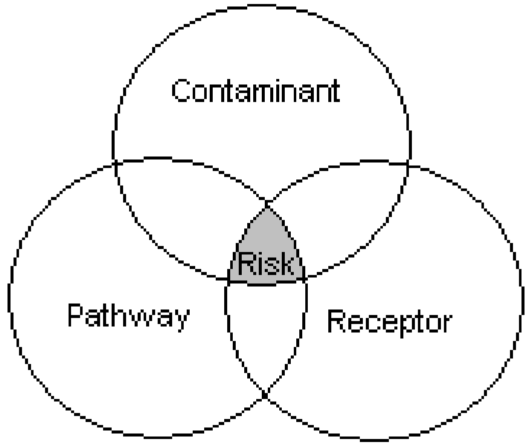


Figure 2.1-1: Venn Diagram Showing the Three Conditions that must Exist for there to be a Potential Health Risk (modified from CCME 1996).

To determine whether these conditions are present, the RA framework used in Canada typically involves 4 components, as described below and depicted in Figure 2.1-2:

i) Problem formulation: The problem formulation involves developing a focused understanding of how environmental quality might affect the health of receptors (i.e., wildlife) near the proposed project. The problem formulation identifies the following:

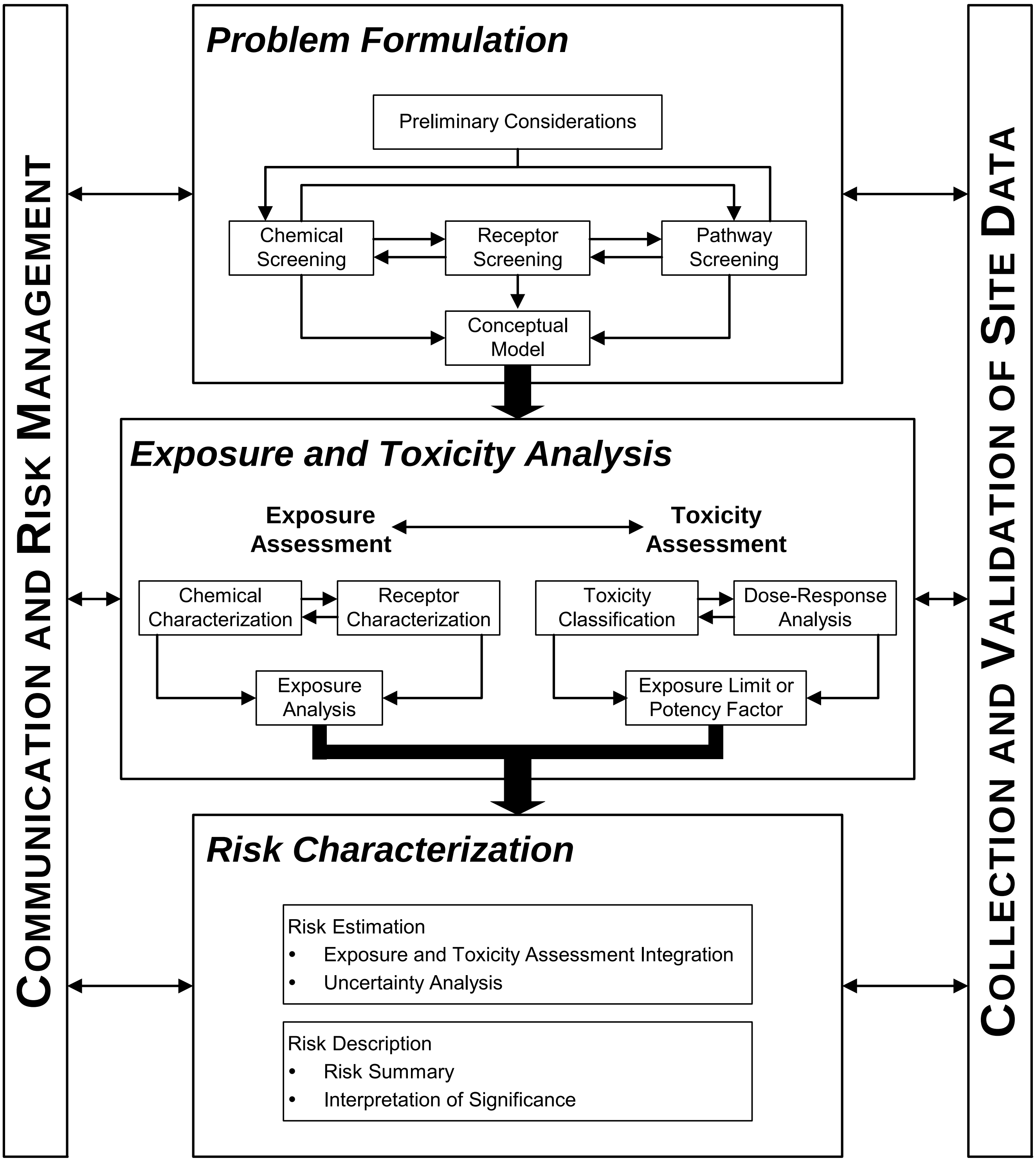
- a representative set of receptors (i.e., wildlife) that may be present in the vicinity of the project;
- chemicals that may be present at levels that may be harmful to receptors. These are termed Chemicals of Potential Concern (COPCs); and
- pathways by which receptors may be exposed to COPCs (e.g., direct contact with soil).

The information from the problem formulation is summarized in a conceptual site model which illustrates the pathways of the COPCs from their sources, through the relevant environmental media and to the receptors of interest.

ii) Exposure assessment: The exposure assessment involves estimating the daily dose of a COPC received by the receptors for each relevant exposure pathway identified in the problem formulation. This value is called the Estimated Daily Intake (EDI) and is typically expressed as milligrams (mg) of a chemical per kilogram (kg) of body weight per day (mg/kg/day). The EDI is calculated from site-specific concentrations of COPCs in environmental media (e.g., water, sediment, fish, air, soil, or vegetation), the amount of time the receptor spends in the study area and receptor-specific parameters such as body weight, ingestion rate, and dietary preferences.

iii) Toxicity assessment: The toxicity assessment provides the basis for assessing what is an acceptable dose and what dose may adversely affect the health of receptors. This involves identification of the potentially toxic effects of a COPC and determination of the dose to which a receptor can be exposed without experiencing adverse health effects. This value is called the Toxicity Reference Value (TRV). For wildlife, the TRV is expressed as mg of a COPC per kg of body weight per day (mg/kg/day).

iv) Risk characterization: The final component of an RA determines the potential for adverse health effects to occur. This is determined by comparing the dose received by the receptors (i.e., the EDI from the exposure assessment) with the dose that is determined to be acceptable (i.e., the TRV from the toxicity assessment). The characterization of risks includes consideration of the uncertainty and conservatism in the RA.



Source: Health Canada [unpublished] 1995.

Figure 2.1-2: Risk Assessment Framework. Modified from Health Canada (1995b).

2.2 General Approach

2.2.1 Pathway Analysis

In mining projects, potential impacts can only occur where there is a direct link between a project component or activity and the environment. Therefore, the WHRA focused on those components or activities of the NICO Project that could result in NICO Project-related emissions to the environment and corresponding potential effects to wildlife. Those components or activities of the NICO Project that could result in emissions to the environment were determined based upon the Project Description and the potential for releases of Project-related COPCs during the various phases of the Project (i.e., construction, operations, closure, and post-closure; as summarized in Section 1.3), considering all proposed environmental design features and mitigation measures outlined in the DAR (Fortune 2011). This pathway analysis (the identification of the linkages between the NICO Project components or activities and corresponding potential effects to wildlife) are summarized in Appendix A. Pathways were determined to be primary, secondary (minor), or as having no linkage, as described below:

- No linkage – pathway is removed by environmental design features and mitigation so that the NICO Project results in no detectable environmental change and effects to wildlife relative to baseline or guidelines values;
- Secondary – pathway could result in a minor environmental change, but would have a negligible effect on wildlife relative to baseline or guideline values; and
- Primary – pathway is likely to result in a measureable environmental change that could contribute to effects on wildlife relative to baseline or guidelines values.

Primary pathways require further analysis to determine the environmental significance from the NICO Project on wildlife. Pathways with no linkage to wildlife or that are considered minor (secondary) are not analyzed further because environmental design features and mitigation will remove the pathway (no linkage) or effects to wildlife can be determined to be negligible through a simple qualitative evaluation of the pathway. Pathways determined to have no linkage to wildlife or those that are considered to be secondary are not predicted to result in environmentally significant effects to wildlife. All primary pathways were assessed further in the WHRA. The primary pathways assessed further in the WHRA are described below:

- Discharge of treated water from the ETF to Peanut Lake during operations, and potential impacts on downstream waterbodies including Burke Lake and the Marian River;
- Particulate deposition to land (i.e., onto soil and vegetation) and waterbodies during the construction and operations phases;
- Discharge of untreated water from the Open Pit upon flooding of the pit during post-closure to Peanut Lake (as a contingency, pit water may be treated prior to discharge to Peanut Lake either through chemical/biological means within the pit or via the re-commissioned ETF); and
- Seepage of metals from the CDF during post-closure.

2.2.2 Assessment Scenarios

To determine the potential effects of NICO Project-related emissions on wildlife, 2 scenarios were assessed in the WHRA:

- quantitative assessment of exposure to emissions from existing and approved sources (i.e., the Baseline Case); and
- quantitative assessment of exposure to cumulative emissions from existing and approved sources and from the NICO Project (i.e., Project Case).

The scenarios are described further below:

- The Baseline Case was assessed to gain an understanding of the environment as it currently exists without the NICO Project. This scenario used measured concentrations of chemicals in samples of environmental media (i.e., soil, water, sediment, fish and vegetation) collected from the study area.
- The Project Case represents the change to the environment as a result of NICO Project components or activities for all phases of the NICO Project (construction, operations, closure, and post-closure), considering all proposed environmental design features and mitigation measures. This scenario was assessed quantitatively and used predicted concentrations of parameters in environmental media (i.e., air, soil, water, sediment, and vegetation) for the study area. The difference between the Baseline and Project Cases (i.e., Project Case concentration minus Baseline Case concentration) is the incremental change that is expected as a result of NICO Project-related emissions only. The Project Case scenario assessed exposure for the predicted worst-case phase (i.e., of the construction, operations, closure, and post-closure phases) of the NICO Project. It follows that if potential effects on wildlife are acceptable for the predicted worst-case phase of the NICO Project, than potential effects on wildlife for all other phases of the NICO Project will also be acceptable.

A qualitative assessment of exposure due to cumulative emissions was also considered in each component of the WHRA. The Cumulative Effects Case represents the cumulative change to the environment due to the NICO Project as described above and other foreseeable projects, developments, activities, and natural factors that influence the environment. Given that the potential changes to the environment as a result of other foreseeable projects, developments, activities, and natural factors could not be supported with numerical data, the Cumulative Effects Case was qualitatively evaluated.

3.0 DATA USED IN THE WILDLIFE HEALTH RISK ASSESSMENT

To determine the incremental changes in the environment due to emissions from the NICO Project, the existing (or baseline) conditions of the environment must first be understood. Several studies were carried out in support of the NICO Project to characterize baseline environmental conditions. The environmental data collected as part of these studies and used in support of the WHRA are summarized below:

- water quality data for Nico, Peanut, and Burke lakes and the Marian River (Annex C of the DAR);
- sediment quality data for Nico, Peanut, and Burke lakes (Annex C of the DAR);
- fish tissue residue data for lake whitefish and northern pike from Nico, Peanut, and Burke lakes (Annex C of the DAR);
- tissue residue data for a variety of vegetation species (Annex I of the DAR); and
- soil quality data (Annex I of the DAR).

Baseline environmental conditions may change due to emissions from the NICO Project. Therefore, the WHRA also relied upon the following predicted environmental data:

- predicted water concentrations for Nico, Peanut, and Burke lakes and the Marian River for the construction, operation, closure, and post-closure phases of the NICO Project, as determined through water quality modelling (Section 7.0 of the DAR);
- predicted sediment concentrations for Nico, Peanut, and Burke lakes at closure, as determined through sediment quality modelling (Section 7.0 of the DAR);
- predicted soil concentrations for several locations in the study area, as determined using protocols provided in the Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (US EPA 2005b). The calculation of predicted soil concentrations is described further in Section 4.1.4.2 of this report; and
- predicted fish tissue and vegetation concentrations. The calculation of predicted fish tissue and vegetation concentrations is described further in Section 4.2.3.3 of this report.

4.0 WILDLIFE HEALTH RISK ASSESSMENT

4.1 Problem Formulation

The objective of the problem formulation for this assessment was to determine the receptors, chemicals, and exposure pathways of greatest concern for the WHRA. The problem formulation focuses the RA 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 unacceptable health risks are not predicted for the chemicals, receptors, and exposure pathways of greatest concern, it is unlikely that there will be unacceptable health risks for other chemicals, receptors, or exposure pathways.

4.1.1 Assessment and Measurement Endpoints

In the context of RA, assessment endpoints are narrative statements that describe the environmental values to be protected but rarely can they be measured directly. The assessment endpoint in this WHRA was the protection of wildlife that may be exposed to chemicals emitted from the NICO Project from adverse effects on survival, growth, or reproduction. Measurement endpoints are the studies, tests, or models that can be performed that serve as a proxy for the assessment endpoints and are the means by which the risk assessor achieves the assessment endpoint. The measurement endpoints specify what types of data will be collected and how they will be used in the RA. Associated with the measurement endpoints are decision criteria, which specify how the results will be interpreted to help achieve the assessment endpoint. The assessment and measurement endpoints as well as decision criteria used in the WHRA are summarized in Table 4.1-1.

Table 4.1-1: Assessment Endpoints, Measurement Endpoints and Decision Criteria

<table>
<tr><th>Assessment Endpoint</th><th>Measurement Endpoint</th><th>Decision Criteria</th></tr>
<tr><td>Bird survival, growth and reproduction</td><td>Comparison of modeled dietary doses to literature-derived values that represent concentrations at which deleterious effects on survival, growth and reproduction ((NOAEL) for SAR and LOAEL for all other birds) are unlikely.</td><td rowspan="2">Risks were categorized as follows:

Negligible risk: Exposure ratio less than or equal to 1. This conclusion is consistent with standard practice in RA.

Low risk and likely to be negligible: Exposure ratio greater than 1 but less than or equal to 10. This conclusion is generally true but should be reviewed on a chemical-specific basis, as the conservatism of the analysis varies dependent on a number of factors used in the assessment.

Potentially elevated risk: Exposure ratio greater than 10; adverse effects are possible due to the chemical in questions.

Chemicals with exposure ratios greater than 1 were further assessed in a magnitude of effects assessment to determine whether they are truly of concern, considering, upper-bound and central tendency estimates, Project Case and Baseline Case risks, and conservatism in the exposure estimates and toxicity reference values.</td></tr>
<tr><td>Mammal survival, growth and reproduction</td><td>Comparison of modeled dietary doses to literature-derived values that represent concentrations at which deleterious effects on survival, growth and reproduction ((NOAEL) for SAR and LOAEL for all other mammals) are unlikely</td></tr>
</table>

NOAEL = No Observed Adverse Effect Level; LOAEL = Lowest Observed Adverse Effect Level; SAR = Species at Risk; RA = Risk Assessment.

Survival, growth, and reproduction of individuals (mammals and birds) are assessment endpoints that are most appropriate for threatened and endangered species because impairment of individuals could imperil populations. Because reproduction is pertinent to the viability of populations and because assessment endpoints at the population level are challenging to evaluate, this assessment endpoint (survival, growth, and reproduction of individuals) was used for all receptors identified for the WHRA.

4.1.2 Receptors Evaluated

The objective of this step was to select a representative set of wildlife receptors that may be exposed to chemicals emitted by the NICO Project for evaluation in the WHRA. 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. In order to satisfy the requirements of the TOR, specific receptors such as caribou and other federal Species at Risk (SAR) have been included in the assessment.

Within the region, wildlife represents an integral part of the terrestrial environment and many species have important ecological, cultural, social, and/or economic value, and are referred to as valued components (VCs). Valued components may be represented by either individual species or a guild (a group of organisms that exhibit similar habitat requirements and that respond in a similar way to changes in their environment). Wildlife VCs were selected as part of the Wildlife and Wildlife Habitat Baseline Report (Annex D of DAR). The VCs were selected based on several criteria including the following:

- species that reflect the interests of regulatory agencies and First Nations groups, communities, and other people with an interest in the NICO Project;
- ecological, social, cultural and economic aspects of the ecosystem;
- territorial (NWT General Status Ranking Program 2009, internet site) and federal (SARPR 2009, internet site) listed species; and
- current experience with environmental assessments and effects monitoring programs in the NWT and Nunavut.

The Wildlife and Wildlife Habitat Baseline report (Annex D of the DAR) presents a review and interpretation of qualitative and quantitative information from the literature, and data collected during the 2003 to 2010 field programs for the NICO Project for all VCs and other wildlife species.

Wildlife receptors were selected based on several criteria. First, wildlife species that have been selected as VCs by the Wildlife and Wildlife Habitat component were considered as potential receptors. These receptors, including caribou and SAR, were included in the WHRA to satisfy the requirements of the TOR. Second, wildlife receptors were selected based on their potential for exposure. Wildlife that have been identified by the Wildlife and Wildlife Habitat component in the NICO Project area or potentially present in the area were considered as potential receptors (Annex D of the DAR). As well, wildlife that are expected to be present in the NICO Project area for the majority of their lifespan or that have small territories were included as receptors in the WHRA. Third, species present or expected to be present in the NICO Project area and that are territorial (NWT General Status Ranking Program 2009, internet site) and federal (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2009, internet site; SARPR 2009, internet site) listed species were considered as potential receptors. Fourth, additional wildlife species (e.g., arctic ground squirrel and snow shoe hare) were selected that play important roles in the food web (e.g., top predators, major herbivores, key prey species). Finally, receptors with sufficient characterization data to facilitate calculations of exposure and health risks were considered as potential receptors. The receptors evaluated in the WHRA, including rationale for their inclusion are presented in Table 4.1-2.

Of the VCs selected by the Wildlife and Wildlife Habitat component, only one was not evaluated in the WHRA, the marten (*Martes americana*). The wolverine, which was also selected as a VC by the Wildlife and Wildlife Habitat component was evaluated instead of the marten because the wolverine, like the marten, belongs to the weasel family, is carnivorous and is present in the NICO Project area but the wolverine has more sensitive territorial and federal status than the marten.

The arctic ground squirrel and snowshoe hare were added to the list of wildlife receptors because they are important food sources for carnivores (e.g., short-eared owl and wolverine). Amphibian receptors were eliminated from further assessment as these receptors were not identified in the NICO Project area (Annex D of the DAR).

A description of the diet and habitat for all of the receptors selected for evaluation in the WHRA is presented below. The dietary descriptions provided in Table 4.1-2 are simplified from the descriptions found in the next section.

Table 4.1-2: Receptors Evaluated

Species	NWT General Status Rank[a]	COSEWIC Status[b]	SARA Schedule[c]	Feeding Guild	Diet	Rational for Inclusion
Mammals						
Arctic ground squirrel	Secure	Not Listed	Not Listed	Herbivore	Seeds	Potentially present in the NICO Project area, play a key role in the food web (food source for higher order carnivores, herbivore)
Black bear	Secure	Not at Risk	Not Listed	Omnivore	Seeds, berries, insects and small prey	Selected as a VC by the Wildlife and Wildlife Habitat component, identified in the NICO Project area
Caribou	Sensitive	Threatened	Schedule 1 - Threatened	Herbivore	Plant leaves and stems	Identified as a KLOI in the TOR, selected as a VC by the Wildlife and Wildlife Habitat component, identified in the NICO Project area, territorial and federal status, prey species for large carnivores, important subsistence, economic and cultural species
Moose	Secure	Not Listed	Not Listed	Herbivore	Plant leaves and stems	Selected as a VC by the Wildlife and Wildlife Habitat component, identified in the NICO Project area, prey species for large carnivores, important subsistence and cultural species
Muskrat	Secure	Not Listed	Not Listed	Herbivore	Aquatic plant leaves and stems	Selected as a VC by the Wildlife and Wildlife Habitat component, identified in the NICO Project area, prey species for large carnivores, important economic and subsidence species
Snowshoe hare	Secure	Not Listed	Not Listed	Herbivore	Plant leaves and stems	Potentially present in the NICO Project area, play a key role in the food web (food source for higher order carnivores, herbivore)
Wolverine	Sensitive	Special Concern	No Status	Carnivore	Small mammals, carrion	Selected as a VC by the Wildlife and Wildlife Habitat component, identified in the NICO Project area, territorial and federal status

Table 4.1-2: Receptors Evaluated (continued)

Species	NWT General Status Rank[a]	COSEWIC Status[b]	SARA Schedule[c]	Feeding Guild	Diet	Rational for Inclusion
Birds						
Common nighthawk	At Risk	Threatened	Schedule 1 - Threatened	Insectivore	Insects	Upland breeding birds such as the common nighthawk were selected as a VC in the Wildlife and Wildlife Habitat component, identified in the NICO Project area, small territory size, territorial and federal status
Loon	Secure	Not at Risk (common loon)	Not Listed	Piscivore	Fish	Waterbirds such as the loon were selected as a VC in the Wildlife and Wildlife Habitat component, identified in the NICO Project area, play a key role in the food web (only piscivorous bird identified in the NICO Project study area), may be important for subsistence
Mallard	Secure	Not Listed	Not Listed	Herbivore	Insects and larvae, aquatic invertebrates, seeds, , and aquatic vegetation	Waterbirds such as ducks were selected as a VC in the Wildlife and Wildlife Habitat component, identified in the NICO Project area, play a key role in the food web (herbivore), may be important for subsistence
Olive-sided flycatcher	At Risk	Threatened	No Status	Insectivore	Flying insects	Upland breeding birds such as the olive-sided flycatcher were selected as a VC in the Wildlife and Wildlife Habitat component, identified in the NICO Project area, small territory size, territorial and federal status
Peregrine falcon	Sensitive	Special Concern	Schedule 1 - Threatened) Schedule 3 - Special Concern[d]	Carnivore	Small birds and mammals	Raptors such as the peregrine falcon were selected as a VC in the Wildlife and Wildlife Habitat component, identified in the study area, territorial and federal status, play a key role in the food web (carnivore)
Willow ptarmigan	Secure	Not Listed	Not Listed	Herbivore	Plant leaves and stems	Large potential for exposure (i.e., potentially present in the NICO Project area, not migratory), play a key role in the food web (prey species, herbivore), may be important for subsistence

Table 4.1-2: Receptors Evaluated (continued)

Species	NWT General Status Rank[a]	COSEWIC Status[b]	SARA Schedule[c]	Feeding Guild	Diet	Rational for Inclusion
Rusty blackbird	May be at Risk	Special Concern	Schedule 1 - Special Concern	Insectivore	Insects	Upland breeding birds such as the rusty blackbird were selected as a VC in the Wildlife and Wildlife Habitat component, identified in the NICO Project area, small territory size, territorial and federal status
Short-eared owl	Sensitive	Special Concern	Schedule 3 - Special Concern	Carnivore	Small mammals	Raptors such as the short-eared owl were selected as a VC in the Wildlife and Wildlife Habitat component, identified in the study area, territorial and federal status, play a key role in the food web (carnivore)

[a] NWT (Northwest Territories) General Species Ranking Program (2009, internet site).

[b] COSEWIC (Committee on the Status of Endangered Wildlife in Canada) (2009, internet site).

[c] SARA (Species at Risk Act) (SARPR 2009, internet site).

[d] The SARA Schedule for the peregrine falcon is dependent on the subspecies present.

4.1.2.1 Description of Diet and Habitat for Receptors

4.1.2.1.1 Arctic Ground Squirrel

The arctic ground squirrel was added to the list of wildlife receptors because it is an important food source for carnivores identified in the NICO Project area. The habitat of the arctic ground squirrel is limited by permafrost. Typical habitats include eskers, moraines, riverbanks, lakeshores, sand banks, and meadows. The arctic ground squirrel is primarily herbivorous. It eats a variety of tundra vegetation such as leaves, seeds, stems, flowers, grass roots, and fruit. In addition, it may eat carrion, eggs, other ground squirrels and even some nesting birds. The arctic ground squirrel inhabits tundra and forest clearings from eastern Siberia to Hudson Bay. In North America, its range dips south of the sixtieth parallel only in northern British Columbia, and is widely separated from the ranges of other ground squirrel species (Yukon Government 2010, internet site).

4.1.2.1.2 Black Bear

Black bears are found below the treeline in the NWT (ENR 2009, internet site). Black bears are listed as ‘secure’ in the NWT (NWT General Status Ranking Program 2009, internet site) and are not listed federally (COSEWIC 2009, internet site; SARPR 2009, internet site). Black bear sign, including scat and bear skull and jaw remains, was found at 13 locations in the wildlife LSA in September 2003 (Fortune 2004).

Black bears require habitat that provides them with cover for security and an abundance of forage; therefore, preferred black bear habitat is a mixture of forested and open areas (Lariviére 2001; ENR 2009, internet site). Black bears also require secluded areas for denning. Dens may be made in tree cavities, crevices, caves, or under large rocks (Lariviére 2001; ENR 2009, internet site).

Black bears are omnivorous but most of their diet consists of herbaceous vegetation. Horsetails, graminoid species, and animal matter make up the majority of black bear early spring diet (Beeman and Pelton 1980; Graber and White 1983; Raine and Kansas 1989; Schwartz and Franzmann 1991; Lariviére 2001; ENR 2009, internet site). Bears prey on moose calves from birth until approximately 30 days of age, at which time moose calves are able to outrun the bears (Schwartz and Franzmann 1991). Snowshoe hares (*Lepus americanus*), adult moose carcasses, and birds and their eggs also make up an important part of early spring black bear diet (Schwartz and Franzmann 1991).

Later in the spring and throughout the summer, insects become more important staples in black bear diets (Beeman and Pelton 1980; Graber and White 1983; Raine and Kansas 1989). Most of the build up of fat reserves for the winter hibernation comes from berries, which make up the majority of the late summer and fall diet (Lariviére 2001; ENR 2009, internet site; Beeman and Pelton 1980; Graber and White 1983; Raine and Kansas 1989).

4.1.2.1.3 Caribou

Three ecotypes of caribou exist in the NWT. Barren-ground caribou migrate between the barren-ground tundra and the boreal forest. Woodland caribou can be separated into 2 ecotypes – northern mountain and boreal caribou. Northern mountain woodland caribou are migratory and inhabit slopes of the Mackenzie Mountains to the NWT-Yukon Border (ENR 2009, internet site). In general, boreal woodland caribou are not migratory and inhabit forested areas year round. Boreal woodland caribou (hereafter referred to as woodland caribou) may be present within the RSAs year round, whereas barren-ground caribou are expected to be present within the RSAs during the winter.

Habitat selection and caribou behaviour are frequently the result of their response to environmental conditions; therefore, caribou can be found in a variety of habitat types at any one time (Case et al. 1996). The selection of habitat appears to be related to food availability, ease of travel, relief from insects, and predation (Curatolo 1975). Cows with calves play an important role in influencing caribou behaviour because they direct the overall movements of the herd and pass on traditional movement patterns (Curatolo 1975).

Woodland caribou prefer mature to old conifer forests since these habitats contain lichen, which is the caribou's primary winter food source (Dzus 2001). Woodland caribou primarily select peatland-dominated landscapes, such as black spruce bogs and black spruce-tamarack fens, while typically avoiding upland areas; however, caribou will use lichen-rich jack pine stands (Stuart-Smith et al. 1997). Woodland caribou tend to calve in low-lying areas, such as muskeg bogs and fens (Dzus 2001).

A wide range of forage plants are used by caribou and food habits vary seasonally (Banfield and Jakimchuk 1980). Caribou are not typically browsers and most of the early winter diet consists of lichens (genera *Cladonia* and *Cladina* spp. preferred) and the green parts of sedges (*Carex* spp.), and horsetails (*Equisetum* spp.) because of their high digestibility and high protein levels (Miller 1976; Case et al. 1996). The consumption of grasses and sedges diminishes over winter, as these plants become less digestible (Kelsall 1968). In late winter, lichens are used extensively, although alder (*Alnus* spp.), birch (*Betula papyrifera*), and willow (*Salix* spp.) may be consumed when other food resources are scarce. Snow characteristics, such as hardness and depth, can influence forage availability and the selection of winter habitat (Case et al. 1996; Dzus 2001). Snow cover, rather than food availability, appears to limit the capacity of winter ranges to support barren-ground caribou. In spring, lichen uplands are the first areas to become snow free, and shrubby lichens become important until new plant growth emerges. Unique habitat features sought out by caribou include mineral licks of frost or mud boils, which are primarily mounds of silt and clay (Pruitt 1960).

Lichen provides a good source of energy but it is not rich in protein (Miller 1992, internet site). Therefore, in spring and summer, caribou tend to select new plant growth and flowers, which are rich in minerals and protein (Thompson and McCourt 1981; Miller 1992, internet site). During the calving season, willow, dwarf birch (*Betula glandulosa*), green alder (*Alnus crispa*), and cotton grass (*Eriophorum* spp.) are consumed as new growth emerges (Fleck and Gunn 1982). Following calving, caribou will move to areas where new vascular plants are more abundant. Willow, forbs, grasses, and sedges become important forage species in summer (Case et al. 1996; Demarais and Krebs 2000). By late summer, the leaves of deciduous shrubs, such as willow, dwarf birch, and bearberry (*Arctostaphylos* spp.), form much of the diet (Skoog 1986). In the fall, grasses, sedges, mushrooms, birch, and willow leaves remain important because of the protein content (Miller 1992, internet site).

4.1.2.1.3.1 Barren-ground Caribou

All herds of barren-ground caribou present in the NWT appear to have declined over the past 5 to 10 years (NWT General Status Ranking Program 2009, internet site; Vors and Boyce 2009; but see Fisher et al. 2009). As a result, all herds of barren-ground caribou in the NWT (with the exception of Peary caribou) are ranked as 'sensitive' in the NWT (NWT General Status Ranking Program 2009, internet site).

Although the precise timing and location of barren-ground caribou movements between winter ranges and calving grounds are unpredictable, general corridors and the broad timing of movements are known. Caribou movements are generally classed into 6 periods (biological seasons) based on satellite-collared caribou data (ENR 2009, internet site). Barren-ground caribou migrate from wintering grounds in the boreal forest, north to calving grounds in the tundra. Pregnant cows lead the northern migration in late winter/early spring, followed by juveniles and bulls (Miller 1992, internet site). After calving, cows and calves begin to migrate back to the winter range. As spring turns into summer, the cows meet up with the bulls that have continued to travel north (ENR 2009, internet site). In August and September, the caribou move across the tundra towards the treeline. The rut occurs in October, and may last for 2 to 3 weeks. The distribution of barren-ground caribou changes constantly during the winter as they search for places where the food is abundant and the snow is the shallowest (ENR 2009, internet site). When spring arrives, the caribou once again begin their migration to the calving grounds.

The occurrence of barren-ground caribou in the RSAs was estimated from the presence of satellite-collared animals from the Bathurst, Ahiak, and Bluenose East herds (Annex D of DAR). The study area falls within the area commonly used by wintering Bathurst caribou (Annex D of DAR). The Ahiak and Bluenose East caribou herds also have the potential to use the study areas during the winter months (Annex D of DAR).

4.1.2.1.3.2 Woodland Caribou

Most woodland caribou populations have also declined in recent years (ENR 2009, internet site). The boreal ecotype of woodland caribou is listed as 'sensitive' in the NWT (NWT General Status Ranking Program 2009, internet site) and 'threatened' by COSEWIC (2009, internet site) and SARA (SARPR 2009, internet site). The northern mountain ecotype is 'of special concern' territorially and federally. The southern mountain populations are listed as 'threatened' and the Atlantic (formerly Gaspé) populations are considered 'endangered' (COSEWIC 2009, internet site; SARPR 2009, internet site).

The RSAs fall within the range identified for NWT North Slave woodland caribou population (ENR 2009, internet site). However, personal communication with John Mantla (J. Mantla, Fortune, 2003, pers. comm.; Annex D of DAR), Pierre Beaverho (Whatì, 2011, pers comm.), Jimmy Nitsiza (Whatì, 2011, pers comm.), and Jimmy B. Rabesca (Whatì, 2011, pers comm.) indicated that they knew of no traditional hunting of woodland caribou in the area, and believed that they were not commonly present in the study area Woodland caribou tend to be more common to the west of the RSAs, beyond the community of Whatì (Dogrib Treaty 11 Council 2001).

4.1.2.1.4 Moose

Moose populations in the NWT are listed as 'secure' (NWT General Status Ranking Program 2009, internet site), and are not listed federally (COSEWIC 2009, internet site; SARPR 2009, internet site). Traditional moose range encompasses suitable habitat south of the treeline throughout the NWT. However, since the early 1900s, moose have been seen at numerous locations on the tundra where adequate forage is available (ENR 2009, internet site). Moose were documented in the proposed mine RSA (Annex D of DAR).

Optimal moose habitat consists of deciduous shrub and ground layers within deciduous, mixed, and conifer forests that offer edge or disturbed areas of early successional vegetation (Poole and Stuart-Smith 2003; Osko et al. 2004). Deciduous browse is a primary food source, varying from twigs and bark in the winter, to leaves in the spring and summer (URSUS and Komex 1997). In spring, moose tend to seek out low elevation areas, usually wetlands, muskeg, and river floodplains, as this is typically where the first green-up occurs (Stelfox 1993). Moose obtain the majority of their annual salt requirements from pond lilies and aquatic vegetation (Stelfox 1993). They tend to continue to use these areas in the summer periods where they will also feed in adjacent forest stands. Habitat preference of moose during all study periods and study areas could not be determined because the number of moose tracks detected among habitats was not adequate (i.e., expected frequencies of moose tracks among habitats were less than 5).

During summer, moose use upland forests and eat fresh shoots and leaves from deciduous shrubs and young deciduous trees (mainly trembling aspen and balsam poplar). However, moose are also known to browse on young coniferous trees, such as balsam fir, in the summer. Moose diet in summer is typically made up of 74% shrubs and trees, 25% forbs, and 1% graminoids (Rednecker 1987). During the fall and winter, moose typically prefer habitats where adequate browse is available. Preferred fall and winter browse includes red-osier dogwood (*Cornus sericea*), willow species, trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), dwarf birch, alder, and beaked hazelnut (*Corylus cornuta*), among others (Stelfox 1993). To access this forage, habitats with high cover of shrub species, such as shrubby fens and bogs and riparian habitats with open canopies, are usually preferred, particularly in late winter. Shrub height is important during winter conditions, as forage shrub species must be higher than the snowpack to be accessed by moose.

4.1.2.1.5 Muskrat

Muskrats occur throughout most of North America, with the exception of Florida and coastal Georgia and South Carolina (Allen and Hoffman 1984). Muskrat are listed as ‘secure’ in the NWT (NWT General Status Ranking Program 2009, internet site) and are not listed federally (COSEWIC 2009, internet site; SARPR 2009, internet site). Muskrat lodges, feeding platforms, scat, and individuals were observed during ground surveys completed in September 2003 (Annex D of DAR).

Muskrats occur in marshes, ponds, lakes, and slow-moving rivers. Water at a site must be deep enough to not freeze in the winter, but shallow enough to allow the growth of aquatic vegetation (ideal water depth is between 1 and 2 m) (Aleksiuk 1986, internet site). Muskrats build a variety of structures depending on habitat conditions. Along rivers, where bank substrate is appropriate for digging, they construct extensive burrows with underwater entrances as a defense against predators. In marshes, muskrat build lodges out of vegetation and mud. They also build feeding platforms and “push ups,” shelters made of vegetation that cover a hole in the ice, which are used for feeding and as breathing holes.

Muskrats are primarily herbivores, although they will eat some animal matter (Allen and Hoffman 1984). Broad-leaved cattail (*Typha latifolia*) is a preferred food source (Bellrose 1950) and can support 2 to 7 times as many individuals as other vegetation types (Allen and Hoffman 1984). Stream dwelling muskrats tend to have more diverse diets than those that live in marshes. Individuals that inhabit lakes are more opportunistic feeders and may ingest more animal matter than other populations (Allen and Hoffman 1984).

4.1.2.1.6 Snowshoe Hare

The snowshoe hare was added to the list of wildlife receptors because it is an important food source for carnivores identified in the area. Snowshoe hares are active year-round and are commonly found in forests and areas with dense shrub cover (Gadd 1995; Smith 1993; Towers 1980). During the summer, snowshoe hares consume grasses, green vegetation, willow, and berries. In the winter, when green vegetation is scarce, hares consume conifer buds and bark of aspen, alder, and willow trees (Whitaker Jr. 1996).

4.1.2.1.7 Wolverine

Wolverine, the largest member of the weasel family, has a circumpolar distribution in the tundra, taiga plains, and boreal forests (Weir 2004). The western Canada population, including NWT and Nunavut, is listed as a species ‘of special concern’ (COSEWIC 2009, internet site) and currently has no status under SARA (SARPR 2009, internet site). Wolverine status in the NWT is considered ‘sensitive’ (NWT General Status Ranking Program 2009, internet site). Wolverines are an important cultural and economic resource for people of the

NWT. Traditional knowledge indicates that wolverines were harvested primarily for their fur, although historically they were sometimes killed as an emergency food source. Although there was a low frequency of sign observed (Annex D of DAR), it is likely that wolverines are present year round in the study area and the surrounding region. Wolverine abundance would be expected to increase during winters when caribou are present in the study area. The RSAs include a number of boulder areas that are potential wolverine denning habitats (Fortune 2004).

Wolverines are associated with a variety of habitat types (Hatler 1989). Habitat use typically depends on adequate food resources and den site availability. Wolverines occur more frequently where large ungulates are common and where carrion is abundant from hunter kills, predation, and natural mortality (COSEWIC 2003). Preferred landscape features appear to depend less on vegetation characteristics, and more on the structure of the terrain and availability of secure hiding cover for dens and food caching (Lofroth 2001). No data are available for wolverine response to wildfire; however, it is likely that wolverine will be negatively influenced by wildfire because they avoid early succession habitats (Copeland 1996).

Den site requirements for wolverines in the boreal forest are not well understood. The persistence of snow cover at a den site through the spring is an important factor for wolverines throughout their range (Magoun and Copeland 1998; Aubry et al. 2007; Copeland et al. 2007).

Wolverines are scavengers and predators that will cache food for future use. Wolverine feed opportunistically and their diet generally reflects annual and seasonal changes in food availability (Magoun 1987). Although wolverines are capable of taking large ungulates as live prey, the presence of ungulates in the diet is mostly the result of scavenging (Hornocker and Hash 1981; Gardner 1985; Banci 1987; Copeland 1996). The remnants of a caribou carcass may be cached in den sites or in deep crevasses of rocky terrain for later consumption. The interdependence of wolverine on other large carnivores such as wolves and black bear to provide carrion is unclear.

Ungulates are important in the wolverine diet year round (Banci 1994), but the summer diet is more varied. Wolverines have been reported to consume minnows in the summer when the water is shallow (LKDFN et al. 1999). Small mammals, such as lemmings and voles, waterbirds and their eggs, ptarmigan, and other wolverines, are also hunted opportunistically (Gardner 1985; Hash 1987; Magoun 1987; Banci 1994; NSMA 1999, internet site). Plants and berries may also be consumed (Banci 1994).

4.1.2.1.8 Upland Breeding Birds – Common Nighthawk, Olive-Sided Flycatcher, and Rusty Blackbird

The spring migration of birds to the NWT begins in early May and peaks around mid- to late May. The breeding season for small perching birds (passerines) typically starts during the first week of June and continues for approximately 3 weeks. Fall migration begins in mid-August for some species such as sandpipers, and continues through to mid-September for late migrants such as horned larks. Common nighthawk, olive-sided flycatcher, and rusty blackbird are federal listed species that were recorded within the RSAs and for that reason have been retained for evaluation in the WHRA.

Nest requirements (e.g., tree cavities) designate where certain bird species will nest and breed. Upland breeding birds nest in a variety of habitats, including woodland, grassland, shrubland, and disturbed habitats. Woodland habitat breeding species (e.g., least flycatcher, Tennessee warbler) were the most numerous species observed during birding bird survey within the LSA and NPAR RSA and accounted for 63% of the 38 upland breeding bird species recorded. Shrubland breeding birds (e.g., yellow warbler, white-throated sparrow) accounted for 21% of the 38 species recorded. Wetland breeding species (e.g., northern waterthrush, red-winged blackbird) accounted for 10% of the species recorded, while open habitat (e.g., common nighthawk) and disturbed habitat nesting species (e.g., eastern phoebe) each accounted for 3% of the 38 species recorded.

Most upland breeding birds observed within the study area are insectivorous, although they will also occasionally eat seeds, fruit, and arthropods (Birds of North America Online 2010, internet site). Some exceptions to this are gray jay, which is omnivorous, and common redpoll, which is primarily a seed eater.

4.1.2.1.9 Waterfowl – Loon and Mallard

The spring migration of waterfowl (e.g., loons, grebes, coots, ducks, and geese) to the NWT begins in early May, and in some years, at the end of April (Łutsel K'e Dene Elders and Land-Users et al. 2003). Throughout generations, people have depended upon ducks and geese to use the same migration routes to reach their staging and nesting areas in the NWT. People travel to these waterfowl staging areas in the spring and fall to harvest the migrating birds, (Lutsel K'e Dene Elders and Land-Users et al. 2002; Golder 2010) and in the summer, they travel to the barren-lands where birds migrate to lay eggs (NSMA 1999, internet site).

Following spring migration, mating pairs of waterfowl select a waterbody or portion of a waterbody (known as a pair pond) as their territory. In the boreal forest, dabbling ducks (e.g., mallard, blue-winged teal) generally nest in heavily vegetated marshes, bogs, shrubland, forests, or on islands. Diving ducks (e.g., canvasback, ring-necked duck) generally nest over water in either emergent vegetation or other structures (e.g., muskrat pushup) but are also known to nest in the uplands near water. Brood rearing occurs on larger wetlands as they provide food sources as well as cover from predators. Waterfowl densities vary with invertebrate presence and biomass as invertebrates are the primary food for most waterfowl species (Elmberg et al. 2000). Waterfowl young are dependent on invertebrates during their first 4 weeks of life because invertebrates satisfy protein requirements for feather development (Hornung 2005). Waterfowl also feed on a variety of submersed vegetation and seeds of emergent vegetation.

4.1.2.1.10 Raptors – Peregrine Falcon and Short-Eared Owl

Raptors are birds of prey and include falcons, eagles, hawks, and owls. Falcon production is known to be seasonally variable and highly dependent upon small mammal and bird populations, and availability of suitable nesting habitat. Raptors are known to be sensitive to disturbances, particularly during breeding, and declines in raptor populations have been attributed to human activities and developments (Craighead and Mindell 1981).

The short-eared owl is listed as a species of 'special concern' under COSEWIC (2009, internet site) and Schedule 3 of SARA (SARPR 2009, internet site). The peregrine falcon is listed on Schedule 1 of SARA (SARPR 2009, internet site). These species are also listed in NWT as 'sensitive' (NWT General Status Ranking Program 2009, internet site). Recently, peregrine populations in the Canadian Arctic have increased due to the decline in the use of organochlorine pesticides in their wintering areas (Shank et al. 1993).

Peregrine falcons prefer to nest on cliffs with open gulfs of air (i.e., not confined areas), but human structures (e.g., skyscrapers) in urban areas can also be used (White et al. 2002, internet site). Peregrines also require open areas for foraging. Birds are the primary prey of peregrines although occasionally small mammals, bats, amphibians, fish, and insects will also be consumed.

The medium-sized short-eared owl routinely nests on the ground. Prey availability is usually the factor that determines breeding locales. Small mammals, particularly meadow vole, dominate the short-eared owl's diet in North America (Semenchuk 1992).

4.1.2.1.11 Willow Ptarmigan

The largest and most numerous of North America's 3 species of ptarmigan, the willow ptarmigan is a characteristic feature of arctic, subarctic, and subalpine tundra. This species has developed a variety of behavioral and physiological adaptations for living in extreme northern environments, where temperatures and light levels vary dramatically and predators abound: feathered tarsi that function as snowshoes, use of snow burrows for shelter, and a complex pattern of molting that results in cryptic plumage year-round. Both the willow ptarmigan and its congener the rock ptarmigan (*Lagopus muta*), have Holarctic distributions; they are the only 2 grouse species with a circumpolar distribution. The willow ptarmigan was retained in the WHRA as it may potentially spend its entire life in the NICO Project area (i.e., it does not migrate south in the winter or north in the summer) and therefore has high potential for exposure.

The breeding range is primarily subarctic or subalpine zones, particularly shrubby habitats in relatively low, moist areas. In Alaska and northern continental Canada, it is common in areas with patches of dense vegetation, especially where willow (*Salix*) or birch (*Betula*) shrubs are abundant and the height of the shrubs range from 0.3 to 2.0 m. It is also found in sedge-willow (*Carex-Salix*) marshes, in meadows, along road and forest edges, and on open tundra. The willow ptarmigan tends to occur on level areas or moderate slopes. In the winter, ptarmigan feed on buds, twigs, catkins while in the summer they feed on leaves, flower buds, twigs, insects, berries, stems, seeds, catkins (Hannon et al. 1998, internet site).

4.1.3 Exposure Pathways Evaluated

The objective of this step was to identify potential pathways by which wildlife could be exposed to COPCs and the relative contribution of these pathways to total exposure. A COPC is 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 COPC to reach a receptor, then there cannot be a risk, regardless of the COPC concentration.

Terrestrial mammals and birds were considered to be exposed to COPCs via incidental ingestion of soil, ingestion of plants and prey that may accumulate COPCs directly or indirectly through the food chain from soil and from ingestion of surface water. Mammals and birds that have a more aquatic habitat (e.g., muskrat, moose, mallard, and loon) were considered to be exposed to COPCs via incidental ingestion of sediment rather than soil, ingestion of plants and prey (i.e., fish) that may accumulate COPCs directly or indirectly through the food chain from surface water/sediment and from ingestion of surface water.

For ingestion of plants, wildlife was assumed to be exposed to COPCs that have been taken up by the plant via uptake from the soil through the roots. Direct deposition onto plants and subsequent ingestion of the plants by wildlife was not evaluated in the WHRA. This was considered appropriate because ingestion of particulates on the plant is included in the fraction of exposure associated with incidental soil ingestion. This approach is consistent with that which was used in the development of the US EPA Ecological Soil Screening Levels (Eco-SSLs) (US EPA 2005a)

Direct exposure, via ingestion, to mine tailings was not considered to be a relevant exposure pathway to wildlife receptors. During operations, the CDF, where the tailings will be placed, will not provide suitable habitat or be attractive to wildlife receptors due to the mining activities, including noise disturbance. Once mining operations are complete, the tailings in the CDF will be caped to prevent direct exposure by wildlife and dust generation.

Exposure to surface water in the Flooded Open Pit, during post-closure, was also considered not to be a relevant exposure pathway for the first 120 years post-closure. As the pit is filling, wildlife would not be able to access the water in the deep pit. Although waterfowl could access the Flooded Open Pit as it is filling, it is unlikely that they would spend much time there due to the absence of food. Therefore, wildlife receptors were considered to be exposed to the Flooded Open Pit surface water once it has filled to surface after 120 years.

The potential exposure pathways for the WHRA are presented in Table 4.1-3, including rationale for their inclusion or exclusion from the assessment.

The potential exposure pathways were evaluated for each phase of the NICO Project, as applicable. Table 4.1-4 summarises the potential wildlife exposure pathways that were evaluated for each phase of the NICO Project.

Table 4.1-3: Exposure Pathways Evaluated

Exposure Pathway	Evaluated	Rationale
Inhalation of air	✘	Wildlife may inhale airborne chemicals resulting from emissions from the NICO Project. Inhalation is a relatively minor exposure pathway for wildlife compared to ingestion of soil, water, prey, and plants (US EPA 2005a). Secondly, there is a general lack of exposure and toxicity related information required to assess this exposure pathway for wildlife receptors, including physiological parameters such as inhalation rates, and toxicological parameters such as Toxicity Reference Values. Therefore, COPCs in air were evaluated based on their potential to be deposited onto soil and waterbodies and then be taken up into plants and prey that may be consumed by wildlife receptors.
Ingestion of soil	✓	Airborne emissions from the NICO 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 WHRA.
Dermal contact with soil	✘	Although wildlife may be exposed by directly contacting soil, birds, fur-bearing mammals and ungulates likely receive insignificant doses through this route relative to other routes, such as direct ingestion of soil, plants and prey due to the presence of fur and feathers (Sample and Suter 1994; US EPA 2005a). Therefore, dermal contact with soil was not evaluated in the WHRA.
Ingestion of plants	✓	Airborne emissions from the NICO Project may deposit directly onto soils. Chemicals may subsequently be taken up into plants that are food sources for wildlife. Consumption of plants could expose herbivorous and omnivorous wildlife to chemicals. Therefore, this exposure pathway was evaluated for herbivorous and omnivorous wildlife receptors (i.e., arctic ground squirrel, black bear, moose, willow ptarmigan, snowshoe hare, and caribou).
Ingestion of prey	✓	Carnivorous and omnivorous animals have the potential to be exposed to chemicals via ingestion of prey. Consumption of prey is a potential exposure pathway for the short-eared owl, wolverine and peregrine falcon, because their prey are herbivores (e.g., arctic ground squirrel and snowshoe hare) and could be exposed to chemicals via plant ingestion. For this reason, ingestion of prey was evaluated in the WHRA for these receptors.
Ingestion of surface water	✓	Airborne emissions from the NICO Project may deposit directly onto surface water bodies. As well, chemicals may be directly emitted to surface water bodies from the NICO Project through water discharges. All wildlife species consume surface water. As such, ingestion of surface water was evaluated for all receptors.

Table 4.1-3: Exposure Pathways Evaluated (continued)

Exposure Pathway	Evaluated	Rationale
Dermal contact with surface water	×	Although wildlife may be exposed by directly contacting surface water, birds, fur-bearing mammals and ungulates likely receive insignificant doses through this route relative to other routes, such as direct ingestion of water (Environment Canada 1994) due to the presence of fur and feathers. Therefore, dermal contact with surface water was not evaluated in the WHRA.
Ingestion of sediment	✓	Airborne emissions from the NICO Project may deposit directly onto waterbodies and settle to the sediments. Wildlife species that feed from the aquatic environment may consume small amounts of sediment during feeding. Therefore, this exposure pathway was evaluated in the WHRA for wildlife that feed from the aquatic environment (i.e., muskrat, moose, loon, and mallard).
Dermal contact with sediment	×	Exposure via dermal contact with sediment is considered insignificant relative to exposure via incidental sediment ingestion (US EPA 2005a). Therefore, this exposure pathway was not evaluated in the WHRA.
Ingestion of fish	✓	Piscivorous wildlife have the potential to be exposed to chemicals via ingestion of fish that have accumulated chemicals from surface water/sediment. Therefore, this exposure pathway was evaluated for wildlife that consume fish (i.e., loon).

✓ = Exposure pathway was evaluated in the wildlife health risk assessment; × = exposure pathway was not evaluated in the wildlife health risk assessment.

Table 4.1-4: Exposure Pathways Evaluated for Each Phase of the NICO Project

Exposure Pathway	Construction Phase	Operations Phase	Active Closure and Post-Closure Phase
Ingestion of soil/sediment	Potential exposure due to dust generation and associated deposition to soils and waterbodies from construction of the mine and supporting infrastructure	Potential exposure due to dust generation and associated deposition to soils and water bodies from mining activities and the NPAR	Potential exposure not considered to increase relative to the operations phase as dust generation and associated deposition to soils and waterbodies will cease once mining activities cease
Ingestion of tailings	No exposure as tailings will not be present	No exposure due to lack of suitable habitat and disturbances from mining activities	No exposure as tailings will be capped
Ingestion of surface water	Potential exposure due to dust generation and associated deposition to waterbodies from construction of the mine and supporting infrastructure	Potential exposure due to dust generation and associated deposition to waterbodies from mining activities and the NPAR, potential exposure due to discharge of effluent from the ETF	Potential exposure due to long-term seepage from the CDF, potential exposure due to discharge from the Flooded Open Pit
Ingestion of Flooded Open Pit surface water	No exposure as water will not be present	No exposure as water will not be present	Potential exposure after 120 years once the pit has filled to surface
Ingestion of plants	Potential exposure due to dust generation and associated deposition to soils and subsequent uptake by plants from construction of the mine and supporting infrastructure	Potential exposure due to dust generation and associated deposition to soils and subsequent uptake by plants from mining activities and the NPAR	Potential exposure not considered to increase relative to the operations phase as dust generation and associated deposition to soils and subsequent uptake by plants will cease once mining activities cease

Table 4.1-4: Exposure Pathways Evaluated for Each Phase of the NICO Project (continued)

Exposure Pathway	Construction Phase	Operations Phase	Active Closure and Post-Closure Phase
Ingestion of prey	Potential exposure due to dust generation and associated deposition to soils and subsequent uptake through the food chain from construction of the mine and supporting infrastructure	Potential exposure due to dust generation and associated deposition to soils and subsequent uptake through the food chain from mining activities and the NPAR	Potential exposure not considered to increase relative to the operations phase as dust generation and associated deposition to soils and subsequent uptake through the food chain will cease once mining activities cease
Ingestion of fish	Potential exposure due to dust generation and associated deposition to waterbodies and subsequent uptake through the food chain from construction of the mine and supporting infrastructure	Potential exposure due to dust generation and associated deposition to waterbodies and subsequent uptake through the food chain from mining activities and the NPAR, potential exposure due to discharge of effluent from the ETF and subsequent uptake through the food chain	Potential exposure due to long-term seepage from the CDF and uptake through the food chain, potential exposure due to discharge from the Flooded Open Pit and uptake through the food chain

CDF = Co-Disposal Facility; ETF = Effluent Treatment Facility; NPAR = NICO Project Access Road

4.1.4 Chemicals Evaluated

Chemicals may be emitted from the NICO Project via airborne emissions and subsequent particulate (dust) deposition to soil and surface water, as well as via discharges to the aquatic environment. Airborne emissions include acid gases, Volatile Organic Compounds (VOCs), Polycyclic Aromatic Hydrocarbons (PAHs), dioxins/furans, and metals. Particulate deposition to soil includes PAHs and metals. Particulate deposition to surface water includes metals only because there is currently no standard method that can be used to accurately model particulate deposition of PAHs to surface water. Acid gases and VOCs remain airborne due to their high vapour pressures, preventing any local deposition onto soils and surface water. If they do deposit, they tend not to persist in soil and water, rapidly biodegrading and volatilizing to the atmosphere. Therefore, acid gases and VOCs were not assessed further in the WHRA but rather the assessment focussed on those chemicals that may potentially deposit, including PAHs and metals. Discharges to the aquatic environment include metals only.

4.1.4.1 Identification of Chemicals of Potential Concern

Chemicals were identified as COPCs and retained for further evaluation in the WHRA if the predicted concentration of the chemical in soil, sediment or surface water was greater than 10% of baseline concentrations and exceeded the appropriate regulatory screening value. If a chemical was identified as a COPC in one medium (e.g., soil), it was retained as a COPC in all other media (e.g., sediment and surface water).

Baseline soil, sediment, and surface water concentrations relied upon in the WHRA were obtained from the following reports:

- Final Report on Baseline Soil and Vegetation Chemistry for the Proposed NICO Project (Annex I of DAR); and
- Final Report - Aquatic Baseline Report for the Proposed NICO Project (Annex C of DAR).

Modelled data relied upon in the WHRA, including particulate deposition rates, surface water concentrations, and sediment concentrations, are provided in Section 7.0: KLOI – Water Quality, and Section 10: Subject of Note – Air Quality of the DAR.

Sections 4.1.4.2, 4.1.4.3, and 4.1.4.4 provide the detailed screening processes used for identification of COPCs in soil, sediment and surface water, respectively.

4.1.4.2 Chemical Screening Process for Particulate Deposition

There are no regulatory guidelines or risk-based concentrations that can be directly compared to deposition rates. Thus, an alternative chemical screening process was used. In brief, the modelled deposition rates were used to calculate incremental soil concentrations, the incremental soil concentrations were added to baseline concentrations and the resulting soil concentrations were compared to baseline concentrations, CCME soil quality guidelines and US EPA soil screening levels protective of wildlife.

Incremental soil concentrations were calculated using protocols provided in the Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (US EPA 2005b). Specifically, equations 1 and 2 were used to calculate the incremental soil concentrations of inorganic and organic chemicals, respectively.

$$\text{ISC (Inorganic Chemicals)} = (100^* \ (Dyd+Dyw)^*tD) \ / \ (Zs \ ^*BD) \quad \textbf{\textit{(1)}}$$

Where:
ISC = Incremental Soil Concentration (mg/kg dw)
Dyd = Dry Deposition Rate ($g/m^2/yr$; Project and chemical specific)
Dyw = Wet Deposition Rate ($g/m^2/yr$; Project and chemical specific)
tD = Deposition Time (21 yr; Project specific)
Zs = Soil Mixing Depth (0.02 m untilled land; US EPA 2005b)
BD = Bulk Density (1.5 g/cm^3; US EPA 2005b)

$$\text{ISC (Organic Chemicals)} = [(100^*(Dyd+Dyw)^*[1-\exp(-Ks \ ^* \ tD)]/(Zs^*BD^*Ks)] \quad \textbf{\textit{(2)}}$$

Where:
ISC = Incremental Soil Concentration (mg/kg dw)
Dyd = Dry Deposition Rate ($g/m^2/yr$; Project and chemical specific)
Dyw = Wet Deposition Rate ($g/m^2/yr$; Project and chemical specific)
tD = Deposition Time (21 yr; Project specific)
Zs = Soil Mixing Depth (0.02 m untilled land; US EPA 2005b)
BD = Bulk Density (1.5 g/cm^3; US EPA 2005b)
Ks = Soil Loss Constant (yr^{-1}; chemical specific [US EPA 2005b])

The wet and dry deposition rates were modelled at 7 receptor locations, including:

- on-site maximum point of impingement (MPOI) location;
- on-site worker camp;
- fenceline location;
- Bea Lake;

- off-site community of Gamètì;
- off-site community of Whatì;
- off-site recreational location of Hislop Lake; and
- off-site recreational location of Marian River.

A detailed description of the deposition modelling is provided in Section 10 of the DAR. The modelled deposition rates represent a worst case scenario from any phase of the NICO Project (i.e., construction, operations, active closure, and post-closure). As the deposition rates used to predict incremental soil concentrations are a worst case scenario from any phase of the NICO Project, a deposition time of 21 years was used. This included 1 year of construction, 18 years of operation, and 2 years of active closure. All chemicals deposited onto soil were assumed to mix within the top 0.02 m, as recommended for untilled soils (US EPA 2005b). Soil was assumed to have a bulk density of 1500 kilograms per cubic metre (US EPA 2005b). Loss due to weathering and degradation was only assumed for organic chemicals because metals are not degraded by processes such as microbial degradation and photolysis (US EPA 2005b). The calculated incremental soil concentrations for all receptor locations are provided in Appendix B, Table B-1. The incremental soil concentrations for inorganic chemicals were added to the average baseline concentrations and the incremental soil concentrations for organic chemicals were added to the maximum baseline concentrations. The average baseline concentrations were used to predict the inorganic chemical concentrations because of the large variability in the inorganic chemical concentrations in the baseline sampling. The baseline concentrations are provided in Appendix B, Table B-1. Predicted soil concentrations for all receptor locations are provided in Appendix B, Table B-2.

Predicted soil concentrations were compared first to baseline concentrations plus 10% (average baseline concentrations for metals and maximum baseline concentrations for PAHs). Comparison to a threshold of 10% above baseline concentrations was considered to represent a conservative evaluation of whether a measurable NICO Project-related impact to soil was likely to occur. Given spatial and temporal variability, field sampling variability in laboratory methods and the conservatism applied in the predictive deposition modelling, any predicted increased of less than 10% above baseline concentrations was considered unlikely to reflect a considerable change in environmental quality as a result of the NICO Project. Next, predicted soil concentrations were compared to the CCME Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME 2010, internet site) and the US EPA Eco-SSLs (US EPA 2010, internet site). The chemicals in soil were retained as COPCs if the predicted soil concentrations exceeded baseline concentrations plus 10% and exceeded a soil guideline/screening level.

The results of the chemical screening for all receptor locations are provided in Appendix B, Table B-2. Table 4.1-5 presents the results of the chemical screening for the receptor location with the highest predicted soil concentrations only (this location was the MPOI), and only for the chemicals with predicted concentrations greater than baseline plus 10%.

Table 4.1-5: Identification of Soil Contaminants of Potential Concern for the Maximum Point of Impingement as a Result of Particulate Deposition

Chemical	CCME Soil Quality Guideline (mg/kg)[a]	US EPA Ecological Soil Screening Levels (mg/kg)		Baseline + 10%[f] (mg/kg)	Predicted Concentration[g] (mg/kg)	COPC	Rationale
		Mammalian	Avian				
Total Metals							
Aluminum	NV	NV	NV	23977	26821	No	Not considered sufficiently toxic
Antimony	NV	0.27	NV	1.02	**1.97**	**Yes**	**> Baseline + 10% and Screening Value**
Arsenic	17	46	43	167	**281**	**Yes**	**> Baseline + 10% and Screening Value**
Barium	NV	2000	NV	318	343	No	< Baseline + 10%
Beryllium	4[c]	21	NV	1.03	1.11	No	< Baseline + 10%
Bismuth	NV	NV	NV	3.75	60	No	Not considered sufficiently toxic
Cadmium	10	0.36	0.77	0.28	0.31	No	< Screening Value
Calcium	NV	NV	NV	5494	6665	No	Not considered sufficiently toxic
Chromium	64[b]	34	26	20	23	No	< Screening Value
Cobalt	50[c]	230	120	41	53	No	< Screening Value
Iron	NV	NV	NV	7454	17104	No	Not considered sufficiently toxic
Lithium	NV	NV	NV	5.60	6.63	No	Not considered sufficiently toxic
Molybdenum	10[c]	NV	NV	2.64	2.87	No	< Screening Value
Nickel	50	130	210	11	11	No	< Screening Value
Selenium	1	0.63	1.2	0.99	**1.35**	**Yes**	**> Baseline + 10% and Screening Value**
Silver	20[c]	14	4.2	0.23	0.24	No	< Screening Value
Thallium	1.4	NV	NV	0.26	0.29	No	< Screening Value
Tin	50[c]	NV	NV	0.61	1.10	No	< Screening Value
Titanium	NV	NV	NV	627	736	No	Not considered sufficiently toxic
Vanadium	130[c]	280	7.8	28	**29**	**Yes**	**> Baseline + 10% and Avian Screening Value**
PAH Groups							
Sum Low PAH	NV	100[d]	NV	0.24	0.32	No	< Screening Value
Sum High PAH	NV	1.1[e]	NV	2.71	2.47	No	< Baseline + 10%

[a] CCME (Canadian Council of Ministers of the Environment) Soil Quality Guidelines for the Protection of Environmental Health – Residential/Parkland.

[b] Guideline for total chromium.

[c] SQG_{HH} (CCME Soil Quality Guideline for the Protection of Human Health – Residential/Parkland).

[d] Total PAHs – low molecular weight.

[e] Total PAHs – high molecular weight.

[f] Average baseline concentration used for metals; maximum baseline concentration used for PAHs.

[g] Predicted soil concentration at the MPOI (incremental soil concentration from particulate deposition plus average baseline concentration used for metals; incremental soil concentration from particulate deposition plus maximum baseline concentration used for PAHs).

NV = No value; COPC = chemicals of potential concern; PAH = polycyclic aromatic hydrocarbons; mg/kg = milligram per kilogram

Antimony, arsenic, selenium, and vanadium have been retained as COPCs in soil as the predicted concentrations are greater than 10% of baseline concentrations and exceeded soil screening values.

Aluminum, bismuth, calcium, iron, lithium, and titanium do not have soil screening values for comparison and had predicted soil concentrations greater than average baseline concentrations plus 10%. Aluminum is not considered a COPC to mammals and birds when found in soils with a pH > 5.5, due to the low availability and toxicity of the species of aluminum found at this pH (US EPA 2003a). The average soil pH measured in the soil and terrain baseline study for the NICO Project area was 6 (Annex H of the DAR). Furthermore, the maximum measured baseline concentration of aluminum was 60 328 mg/kg, and the predicted concentration at the MPOI of 26 821 mg/kg is well below the maximum measured baseline concentration. Therefore, aluminum was not retained as a COPC.

There is limited toxicological data on exposure to bismuth. One study was found (Sano et al. 2005, internet site) that derived a no observed effect level (NOEL) of 1000 mg/kg based on a 28-day repeated dose study in rats. The maximum predicted concentration of bismuth in soil was calculated to be 60 mg/kg (Table 4.1-5), well below the NOEL of 1000 mg/kg. Therefore, bismuth was not considered sufficiently toxic to retain as a COPC based on predicted soil concentrations.

Iron is a commonly occurring metallic element, comprising 4.6% of igneous rocks and 4.4% of sedimentary rocks. The typical iron concentrations in soils range from 0.2 to 55% (20 000 to 550 000 mg/kg) (US EPA, 2003b), and concentrations can vary significantly, even within localized areas, due to soil types and the presence of other sources. The predicted concentration of iron in soil at the MPOI was calculated to be 17 100 mg/kg, below the typical ranges provided above. Furthermore, the predicted concentration is only slightly greater than the maximum measured baseline concentration of iron of 16 765 mg/kg. Iron is an essential element to terrestrial mammals and birds and is non-toxic at most environmental concentrations. In fact, vertebrates have developed elimination mechanisms to depurate excess iron. Given that iron is a common constituent of soils, that predicted concentrations are well below the typical range found in soils and only slightly above the maximum measured baseline concentration, and that iron is an essential micronutrient and relatively non-toxic at most environmental concentrations, iron was not retained as a COPC. Like iron, calcium is a commonly occurring element in soil and is essential to growth. Calcium was not retained as a COPC.

Lithium and titanium have also been excluded as COPCs. Lithium is widely distributed in nature; trace amounts are found in many minerals, in most rocks and soils, and in many natural waters. Lithium is a member of the alkali metals and does not occur as the free metal in nature. Lithium concentrations in the earth's crust are estimated to be 20 to 70 parts per million by weight; it is the 27th most abundant element (HSDB 2007, internet site). Titanium is the ninth most abundant element in the earth's crust. It is widely distributed in the form of stable minerals and occurs at an average concentration of 4400 mg/kg (HSDB 2003, internet site). Although predicted concentrations at the MPOI for these metals (6.63 mg/kg and 736 mg/kg for lithium and titanium, respectively) are greater than average baseline concentrations plus 10%, predicted concentrations are lower than the maximum measured baseline concentrations of 16.6 mg/kg and 1673 mg/kg for lithium and titanium, respectively. The US EPA (2010, internet site) has developed regional screening levels for lithium and titanium of 160 mg/kg and 140 000 mg/kg, which are significantly higher than the maximum predicted concentrations of 6.63 mg/kg and 736 mg/kg. Although these values were developed to be protective of human health, no other wildlife benchmarks were available. As lithium is not found in its free metal form in nature, titanium is present as a stable mineral and both chemicals were significantly below the maximum measured baseline concentrations and US EPA regional screening levels, neither were considered to be of significant concern to retain as COPCs.

4.1.4.3 Chemical Screening Process for Surface Water

The chemical screening process for surface water included comparison of modelled concentrations of chemicals (95th percentile concentrations) in surface water in Nico Lake, Peanut Lake, Burke Lake and the Marian River for all phases of the NICO Project to average measured baseline concentrations plus 10% followed by comparison to water quality guidelines protective of livestock available from the CCME (2010, internet site) and toxicological benchmarks protective of wildlife available from Sample et al. (1996). The 95th percentile is considered to be more representative of a conservative upper bound of concentrations that would be expected to occur during a dry year, and for this reason the 95th percentile was used for surface water. The chemicals in surface water were retained as a COPC if the predicted surface water concentration exceeded average baseline conditions plus 10% and exceeded a surface water screening guideline/benchmark.

The results of the chemical screening for surface water for all waterbodies and phases of the NICO Project are presented in Appendix B, Table B-3. Table 4.1-6 presents the results of the chemical screening based on the maximum predicted 95th percentile surface water concentrations of all modelled waterbodies (Nico, Peanut, and Burke lakes, and Marian River) and of all phases of the NICO Project (construction, operations, active closure, and post-closure). Only chemicals with predicted concentrations greater than baseline plus 10% are presented in the table. Table 4.1-6 presents the chemical screening for the waterbody and phase of the NICO Project for which the predicted chemical concentrations are the greatest. Chemicals may exceed the surface water screening guidelines/benchmarks in other waterbodies or during other phases of the NICO Project. Refer to Appendix B, Table B-3 for the detailed chemical screening for all waterbodies and phases of the NICO Project.

Arsenic has been retained as a COPC in surface water as the predicted concentration is greater than baseline plus 10% and exceeds the surface water screening guideline during the operations phase of the NICO Project. It should be noted that arsenic exceeds the surface water screening guideline during other phases of the NICO Project (active closure) (Appendix B, Table B-3). Table 4.1-6 indicates the waterbody and phase of the NICO Project for which the predicted arsenic concentrations are the greatest.

Iron does not have surface water screening guidelines/benchmarks for comparison and had predicted concentrations greater than baseline plus 10%. As described above iron was not retained for further assessment. Iron is an essential element to terrestrial mammals and birds and is non-toxic at most environmental concentrations. In fact, vertebrates have developed elimination mechanisms to depurate excess iron. Given that iron is an essential micronutrient and relatively non-toxic at most environmental concentrations, iron was not retained as a COPC.

No other COPCs have been identified in any other surface waterbodies during any other phases of the NICO Project. Therefore unacceptable risks to wildlife from exposure to surface water in Nico Lake during construction and post-closure and in Peanut Lake, Burke Lake, and the Marian River during all phases of the NICO Project are considered negligible.

Table 4.1-6: Identification of Surface Water Contaminants Of Potential Concern for the Waterbody and Phase of the NICO Project for Which Predicted Concentrations are Greatest

Chemical	CCME Guideline[a] (mg/L)	Sample et al. 1996[b] (mg/L)	Baseline + 10%[c] (mg/L)	Predicted Concentration[d] (mg/L)	NICO Project Phase	Waterbody	COPC	Rationale
Aluminum	5	NV	0.04	1.31	Operations	Nico Lake	No	< Screening Value
Antimony	NV	0.29	0.0002	0.004	Post-Closure	Nico Lake	No	< Screening Value
Arsenic	0.03	NV	0.02	**0.04**	Operations	Nico Lake	**Yes**	**> Baseline + 10% and Screening Value**
Barium	NV	23.1	0.02	0.03	Construction	Marian River	No	< Screening Value
Chromium	0.05	NV	0.0002	0.002	Post-Closure	Nico Lake	No	< Screening Value
Cobalt	1	NV	0.001	0.01	Operations	Nico Lake	No	< Screening Value
Copper	0.5	NV	0.002	0.005	Operations	Nico Lake	No	< Screening Value
Iron	NV	NV	0.71	3.3	Operations	Nico Lake	No	Not considered sufficiently toxic
Lead	0.1	NV	0.001	0.002	Post-Closure	Nico Lake	No	< Screening Value
Manganese	NV	377	0.08	0.08	Post-Closure	Nico Lake	No	< Screening Value
Mercury	0.003	NV	0.00004	0.0001	Construction	Marian River	No	< Screening Value
Molybdenum	0.5	NV	0.002	0.01	Post-Closure	Nico Lake	No	< Screening Value
Nickel	1	NV	0.001	0.002	Construction	Marian River	No	< Screening Value
Selenium	0.05	NV	0.0002	0.003	Active Closure	Nico Lake	No	< Screening Value
Uranium	0.2	NV	0.01	0.01	Post-Closure	Nico Lake	No	< Screening Value
Vanadium	0.1	NV	0.0004	0.001	Operations	Nico Lake	No	< Screening Value
Zinc	50	NV	0.003	0.03	Post-Closure	Nico Lake	No	< Screening Value

[a] CCME (Canadian Council of Ministers of the Environment) Water Quality Guidelines for LIfestock Water.

[b] The value provided is the lowest of the NOAEL-based benchmarks for water provided in Table 12 of Sample et al. (1996).

[c] Average measured baseline concentration plus 10%.

[d] Predicted 95[th] percentile concentration.

NV = No value; COPC = chemicals of potential concern; mg/L = milligram per litre

4.1.4.3.1 Chemical Screening Process for Flooded Open Pit Surface Water at Post-Closure

Exposure to surface water in the Flooded Open Pit was considered not to be a relevant exposure pathway for the first 120 years of post-closure as the pit is filling. Wildlife would not be able to access the water in the deep pit. Although waterfowl could access the Flooded Open Pit as it is filling, it is unlikely that they would spend much time there due to the absence of a food source. Therefore, wildlife receptors were considered to be exposed to Flooded Open Pit surface water once it has filled to surface after 120 years.

The chemical screening process included comparison of modelled concentrations of chemicals in Flooded Open Pit surface water at 0 to 120 years, at approximately 120 years and at greater than 120 years to water quality guidelines protective of lifestock available from the CCME (2010, internet site) and toxicological benchmarks available from Sample et al. (1996). The modelled concentrations used were the maximum predicted Flooded Open Pit surface water concentrations. The chemicals were retained as COPCs if the predicted concentrations exceeded a surface water screening guideline/benchmark.

The results of the chemical screening for Flooded Open Pit surface water are presented in Appendix B, Table B-4 for all modelled scenarios (i.e., 0 to 120 years, at approximately 120 years and at greater than 120 years). Table 4.1-7 presents the results of the chemical screening based on the maximum Flooded Open Pit surface water concentrations at approximately 120 years and greater than 120 years after closure.

Table 4.1-7: Identification of Flooded Open Pit Surface Water Contaminants of Potential Concern at Post-Closure

Chemical	CCME Guideline[a] (mg/L)	Sample et al. 1996[b] (mg/L)	Predicted Concentration at ~ 120 years (mg/L)	Predicted Concentration at > 120 years (mg/L)	COPC	Rationale
Aluminum	5	NV	1.30	1.30	No	< Screening Value
Antimony	NV	0.29	0.01	0.01	No	< Screening Value
Arsenic	0.03	NV	**0.27**	**0.24**	**Yes**	**> Screening Value**
Barium	NV	23.1	0.08	0.08	No	< Screening Value
Beryllium	0.1	NV	0.00007	0.0001	No	< Screening Value
Cadmium	0.08	NV	0.0001	0.0001	No	< Screening Value
Chromium	0.05	NV	0.001	0.001	No	< Screening Value
Cobalt	1	NV	0.40	0.32	No	< Screening Value
Copper	0.5	NV	0.01	0.01	No	< Screening Value
Iron	NV	NV	4.15	4.15	No	Not considered sufficiently toxic
Lead	0.1	NV	0.001	0.0005	No	< Screening Value
Manganese	NV	377	0.08	0.07	No	< Screening Value
Molybdenum	0.5	NV	0.02	0.01	No	< Screening Value
Nickel	1	NV	0.02	0.02	No	< Screening Value
Selenium	0.05	NV	0.01	0.01	No	< Screening Value
Silver	NV	0.0015[c]	0.0001	0.0001	No	< Screening Value
Thallium	NV	0.032	0.001	0.001	No	< Screening Value
Uranium	0.2	NV	0.004	0.004	No	< Screening Value
Vanadium	0.1	NV	0.003	0.003	No	< Screening Value
Zinc	50	NV	0.06	0.05	No	< Screening Value

[a] CCME (Canadian Council of Ministers of the Environment) Water Quality Guidelines for Livestock Water.

[b] The value provided is the lowest of the NOAEL-based benchmarks for water provided in Table 12 of Sample et al. (1996).

[c] Ontario Ministry of Environment GW3 value; considered to be protective of terrestrial mammals and birds (MOE 2011).

NV = No value; COPC = chemicals of potential concern; mg/L = milligram per litre

Arsenic has been retained as a COPC in Flooded Open Pit surface water as the predicted concentration exceeds the surface water screening guideline once the pit has filled to surface (~ 120 years). Iron does not have surface water screening values for comparison; however, as described above for the surface water screening, iron was not retained for further assessment given its essentiality and because it is relatively non-toxic to mammals and birds.

4.1.4.4 Chemical Screening Process for Sediment

The chemical screening process for sediment included comparison of modelled concentrations of chemicals in sediment in Nico, Peanut, and Burke lakes to average measured baseline concentrations plus 10% followed by comparison to CCME soil quality guidelines and US EPA Eco-SSLs protective of wildlife. The modelled concentrations were the maximum predicted sediment concentrations at closure. The chemicals in sediment were retained as COPCs if the predicted concentrations exceeded average baseline concentrations plus 10% and exceeded the CCME and US EPA soil guidelines/screening levels protective of wildlife.

The results of the chemical screening for sediment for all waterbodies at closure are presented in Appendix B, Table B-5. Table 4.1-8 presents the results of the screening based on the maximum predicted sediment concentrations of all modelled waterbodies (Nico, Peanut, and Burke lakes). Only chemicals with a predicted concentration greater than average baseline concentrations plus 10% are presented in the table. Table 4.1-8 presents the results of the chemical screening for the waterbody for which the predicted chemical concentrations are greatest. Chemicals may exceed the soil quality guideline/soil screening level in other waterbodies. Refer to Appendix B, Table B-5 for the detailed chemical screening for all waterbodies of the NICO Project.

Nickel exceeds the CCME soil quality guideline of 50 mg/kg, but not the US EPA Eco-SSL mammalian and avian guidelines of 130 mg/kg and 210 mg/kg, respectively. The US EPA Eco-SSLs are more current (2007) than the CCME guidelines (2010, internet site) and have been used to discount nickel as a COPC in sediment.

Antimony, arsenic, chromium, copper, lead, molybdenum, selenium, vanadium, and zinc have been retained as COPCs in sediment as the predicted concentrations are greater than 10% of baseline and exceed soil screening guidelines/levels. Chromium, copper, lead, molybdenum, and zinc have only been identified as COPCs in sediment (not in soil or surface water). Therefore, only those receptors that may be exposed to sediment (e.g., moose, muskrat, loon, and mallard) were assessed for potential effects from exposure to chromium, copper, lead, molybdenum, and zinc. Furthermore, only the mallard and loon were evaluated for potential effects due to exposure to copper and lead, as only the avian screening level was exceeded.

Table 4.1-8: Identification of Sediment Contaminants of Potential Concern for the Waterbody for Which Predicted Concentrations are Greatest

Chemical	CCME Soil Quality Guideline[a] (mg/kg)	US EPA Ecological Soil Screening Levels (mg/kg)		Baseline +10%[d] (mg/kg)	Predicted Concentration[e] (mg/kg)	Waterbody	COPC	Rationale
		Mammalian	Avian					
Antimony	NV	0.27	NV	0.44	**2.58**	Nico Lake	**Yes**	**> Baseline + 10% and Screening Value**
Arsenic	17.00	46	43	530.2	**1090**	Nico Lake	**Yes**	**> Baseline + 10% and Screening Value**
Barium	NV	2000	NV	250.8	317	Burke Lake	No	< Screening Value
Beryllium	4[c]	21	NV	1.1	1.70	Nico Lake	No	< Screening Value
Chromium	64[b]	34	26	78.1	**83**	Burke Lake	**Yes**	**> Baseline + 10% and Screening Value**
Copper	63	49	28	39.05	**44**	Peanut Lake	**Yes**	**> Baseline + 10% and Avian Screening Value**
Lead	300	56	11	11.55	**12**	Burke Lake	**Yes**	**> Baseline + 10% and Avian Screening Value**
Mercury	12	NV	NV	0.055	0.07	Peanut Lake	No	< Screening Value
Molybdenum	10[c]	NV	NV	7.15	**12**	Nico Lake	**Yes**	**> Baseline + 10% and Screening Value**
Nickel	50	130	210	47.3	51	Burke Lake	No	< Screening Value
Selenium	1	0.63	1.2	0.33	**0.69**	Peanut Lake	**Yes**	**> Baseline + 10% and Mammalian Screening Value**
Uranium	500	NV	NV	8.25	8.99	Burke Lake	No	< Screening Value
Vanadium	130[c]	280	7.8	67.65	**72**	Burke Lake	**Yes**	**> Baseline + 10% and Avian Screening Value**
Zinc	200[c]	79	46	148.5	**189**	Nico Lake	**Yes**	**> Baseline + 10% and Screening Value**

[a] CCME (Canadian Council of Ministers of the Environment) Soil Quality Guidelines for the Protection of Environmental Health.
[b] Guideline for total chromium.
[c] SGQ_{HH} (CCME Soil Quality Guideline for the Protection of Human Health – Residential/Parkland).
[d] Average baseline concentration plus 10%.
[e] Maximum predicted sediment concentration at closure.
NV = No value.

4.1.4.5 Final List of Chemicals of Potential Concern

The COPCs that were evaluated in the WHRA for mammals and birds are presented in Table 4.1-9. As noted previously, if a chemical was identified as a COPC in one medium, it was retained as a COPC in all media to determine total exposure.

Table 4.1-9: Chemicals of Potential Concern Evaluated

Chemical	Mammals	Birds
Antimony	✓	×
Arsenic	✓	✓
Chromium	✓	✓
Copper	×	✓
Lead	×	✓
Molybdenum	✓	✓
Selenium	✓	✓
Vanadium	×	✓
Zinc	✓	✓

✓ = Chemical was evaluated in the wildlife risk assessment; × = chemical was not evaluated in the wildlife health risk assessment.

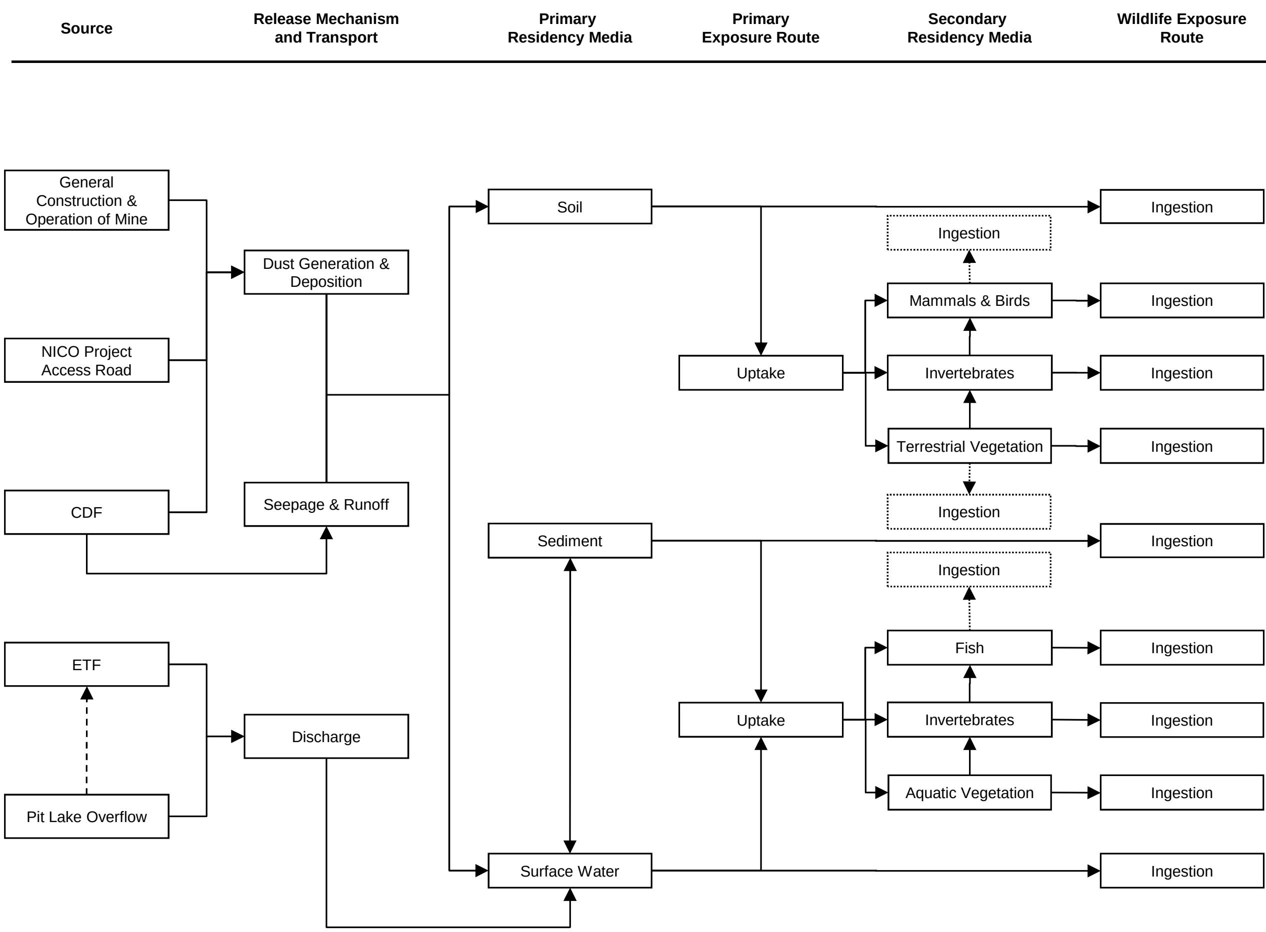
Antimony was not assessed for birds due to a lack of toxicity data (i.e., there are no suitable screening values or TRVs). Copper, lead, and vanadium were not assessed for mammals, as only the avian screening levels were exceeded. Chromium, copper, lead, molybdenum, and zinc have only been assessed for those receptors that may be exposed to sediment (e.g., moose, muskrat, loon, and mallard) as these chemicals were only identified as COPCs in sediment and wildlife with a terrestrial habitat would not be exposed to sediment.

4.1.5 Conceptual Site Model

Taking into account the receptors, exposure pathways and COPCs for the NICO Project area, conceptual site models were developed for the WHRA (Figure 4.1-1 and Figure 4.1-2 for mammalian and avian wildlife, respectively). The model summarizes the NICO Project components/activities, chemical fate and transport, exposure pathways and receptors that were considered in the WHRA.

Conceptual Site Model for the NICO Project for the Wildlife Health Risk Assessment (Mammalian Wildlife)

FIGURE 4.1-1



Receptor

Secondary Residency Media / Wildlife Exposure Route	Arctic Ground Squirrel	Black Bear	Caribou	Moose	Muskrat	Snowshoe Hare	Wolverine
Soil – Ingestion	✓	✓	✓	X	X	✓	✓
Mammals & Birds – Ingestion	X	X	X	X	X	X	✓
Invertebrates – Ingestion	X	✓	X	X	X	X	X
Terrestrial Vegetation – Ingestion	✓	✓	✓	✓	✓	✓	X
Sediment – Ingestion	X	X	X	✓	✓	X	X
Fish – Ingestion	X	✓	X	X	X	X	X
Invertebrates – Ingestion	X	X	X	X	X	X	X
Aquatic Vegetation – Ingestion	X	X	X	✓	✓	X	X
Surface Water – Ingestion	✓	✓	✓	✓	✓	✓	✓

LEGEND

X = Pathway not evaluated in the wildlife health risk assessment or incomplete

✓ = Pathway evaluated in the wildlife health risk assessment

CDF = Co-Disposal Facility

ETF = Effluent Treatment Facility

- - - -▶ = To be treated if water quality does not meet water quality guidelines

··········▶ = Pathway evaluated in the human health risk assessment

Date: November 2011

Project: 09-1373-1004: EC_3

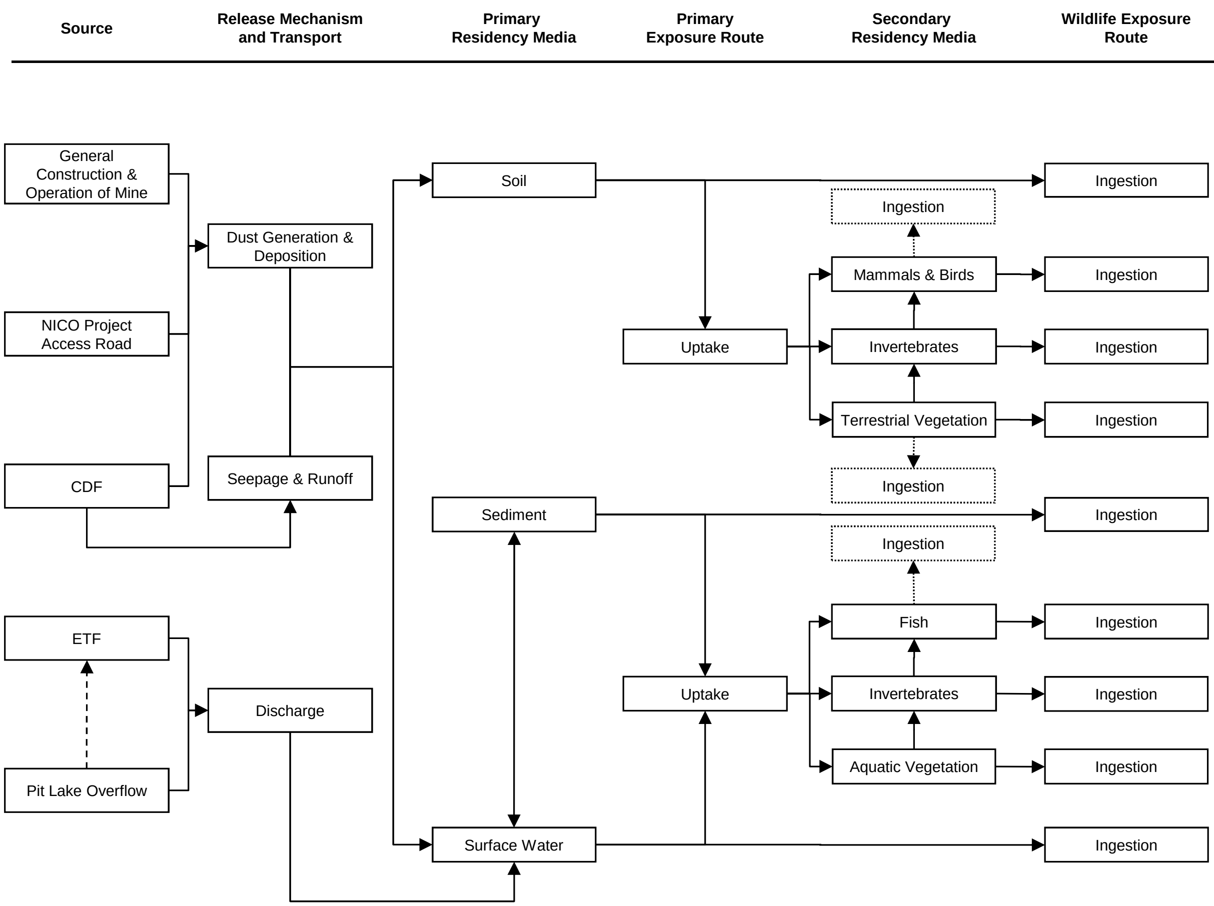
Golder Associates

CAD: SC

CKD: TMG

Conceptual Site Model for the NICO Project for the Wildlife Health Risk Assessment (Avian Wildlife)

FIGURE 4.1-2



Receptor (Wildlife Exposure Route)	Common Nighthawk	Loon	Mallard	Olive-Sided Flycatcher	Peregrine Falcon	Willow Ptarmigan	Rusty Blackbird	Short-Eared Owl
Soil – Ingestion	✓	X	X	✓	✓	✓	✓	✓
Mammals & Birds – Ingestion	X	X	X	X	✓	X	X	✓
Invertebrates – Ingestion	✓	X	✓	✓	X	X	✓	X
Terrestrial Vegetation – Ingestion	X	X	✓	X	X	✓	X	X
Sediment – Ingestion	X	✓	✓	X	X	X	X	X
Fish – Ingestion	X	✓	X	X	X	X	X	X
Invertebrates – Ingestion	X	X	✓	X	X	X	X	X
Aquatic Vegetation – Ingestion	X	X	✓	X	X	X	X	X
Surface Water – Ingestion	✓	✓	✓	✓	✓	✓	✓	✓

LEGEND

X = Pathway not evaluated in the wildlife health risk assessment or incomplete
✓ = Pathway evaluated in the wildlife health risk assessment
CDF = Co-Disposal Facility
ETF = Effluent Treatment Facility
- - - -▶ = To be treated if water quality does not meet water quality guidelines
·········▶ = Pathway evaluated in the human health risk assessment

Date: November2011
Project: 09-1373-1004: EC_3
Golder Associates
CAD: SC
CKD: TMG:

4.2 Exposure Assessment

Exposure assessment is the process of estimating the exposure of a wildlife receptor to a chemical under a given exposure scenario. An exposure assessment was conducted for each COPC identified in the problem formulation. The key components of the exposure assessment for the WHRA included:

- the estimation of the amount of time that wildlife might be expected to be present in the NICO Project area (estimation of probability of exposure);
- a description of the exposure assumptions for environmental media (i.e., concentrations of COPCs assumed in soil, sediment, and surface water);
- a description of the dietary intake assumptions, including dietary preferences, the uptake equations used to estimate COPC concentrations in dietary items and the estimated COPC concentrations in dietary items;
- a description of the receptor-specific exposure parameters used in the assessment including body weights and rates of ingestion of soil/sediment, water, and food; and
- the estimation of the amount of COPCs that wildlife might be exposed to through incidental ingestion of soil or sediment, ingestion of surface water and ingestion of food, be it prey or vegetation.

4.2.1 Estimation of Probability of Exposure

The estimation of probability of exposure for each wildlife species considered the degree of residency (i.e., migrants or non-migrants) near the NICO Project, home range size, and the area of the NICO Project (15 km^2). Degree of residency was calculated as the quotient of the expected number of months that a wildlife species would remain near the NICO Project area over a 12 month biological year (Table 4.2-1). The proportion of time that an individual was exposed to the NICO Project area, while residing in the area, was estimated by dividing the area of the NICO Project by the minimum home range size for the species (i.e., proportion of home range exposed; Table 4.2-1). Using the lower value for home range size likely over estimates exposure and incorporates conservatism into the WHRA.

For species with home ranges that are less than or equal to the NICO Project area, the proportion of time that an individual would spend within the NICO Project area while residing in the area was assumed to be 100%. Therefore, 100% of their food and water was assumed to be acquired from resources within the NICO Project area. In contrast, for wildlife species that have larger home ranges (i.e., caribou and large carnivores) the area of the NICO Project is not large enough to fulfill the seasonal or annual forage requirements of an individual. The overall probability of exposure to the NICO Project area for a species was calculated as the product of the degree of residency and the proportion of the home range exposed (Table 4.2-1).

Table 4.2-1: Estimation of Probability of Exposure

Receptor	Number of Months Near the NICO Project Area	Degree of Residency[p]	Home Range (km^2)	Proportion of Home Range Exposed[q]	Probability of Exposure to COPCs from the NICO Project Area[r]
Arctic ground squirrel	12	1	0.000046[a]	1	100%
Black bear	12	1	75[b]	0.20	20%
Caribou	5[o]	0.42	236,000[c]	0.00006	0.003%
Moose	12	1	174[d]	0.086	8.6%
Muskrat	12	1	0.0017[e]	1	100%
Snowshoe hare	12	1	0.06[f]	1	100%
Wolverine	12	1	105[g]	0.14	14%
Common nighthawk	5[h]	0.42	0.27[h]	1	42% (100%)
Loon	5[i]	0.42	0.05[i]	1	42% (100%)
Mallard	5	0.42	4.7[e]	1	42% (100%)
Olive-sided flycatcher	5[j]	0.42	0.18[j]	1	42% (100%)
Peregrine falcon	12	1	360[k]	0.042	4.2%
Willow ptarmigan	12	1	1.62[l]	1	100%
Rusty blackbird	5[m]	0.42	No data[m]	1	41.67% (100%)
Short-eared owl	5[n]	0.42	No data[n]	1	41.67% (100%)

[a] Government of Nunavut (2011, internet site).

[b] Environment and Natural Resources (2009, internet site).

[c] Calculated from satellite collar data obtained from Environment and Natural Resources, NWT; data is from 1996 to 2010 (Annex D of the DAR).

[d] Stenhouse et al. (1994).

[e] US EPA (1993).

[f] Harestad and Bunnell (1979).

[g] Whitman et al. (1986).

[h] COSEWIC (2007a).

[i] Evers et al. (2010, internet site).

[j] COSEWIC (2007b).

[k] White et al. (2002, internet site).

[l] Gisen and Braun (1992).

[m] COSEWIC (2006).

[n] COSEWIC (2008).

[o] Curatolo (1975); Banfield and Jakimchuk (1980).

[p] Degree of residency was calculated as the expected number of months in the NICO Project area over a 12 month calendar year.

[q] The proportion of the home range exposed was calculated by dividing the area of the NICO Project (15 km^2) by the home range of the receptor.

[p] Probability of exposure was calculated as the product of the degree of residency and the proportion of the home range exposed.

With the exception of the willow ptarmigan and the peregrine falcon, the other bird species assessed in the WHRA are only expected to reside near the NICO Project for 5 months of the year (a degree of residency of 0.42). However, during this time these birds will be breeding and raising young. The TRVs used to assess potential risks to birds are based on reproduction, growth, and development endpoints. It would be less conservative to assume a degree of residency of less than one for these receptors given that they would be present in the NICO Project area during a sensitive life-stage. Therefore it was assumed that the common nighthawk, loon, mallard, olive-sided flycatcher, rusty blackbird, and short-eared owl would have a probability of exposure to COPCs from the NICO Project of 100%.

4.2.2 Concentration Assumptions for Environmental Media (Soil, Surface Water, and Sediment)

Maximum predicted soil (i.e., average baseline concentrations plus maximum predicted incremental soil concentrations), surface water (95^{th} percentile) and sediment concentrations of all the modelled locations in the NICO Project area were used as the exposure point concentrations in the exposure assessment. This a conservative approach as these concentrations were found in isolated locations in the NICO Project area and it has been assumed that receptors will be exposed to these maximum concentrations across the NICO Project area.

It was also assumed that a receptor would be exposed to the maximum concentration of a COPC in all media. That is, it was assumed that the receptor would be exposed to soil at the MPOI (location of the maximum concentrations of COPCs in soil), as well as to surface water at the location of the maximum concentration present in surface water. This too is a conservative assumption in that, for example, the maximum concentration of arsenic in soil found at the MPOI may not be adjacent to the maximum arsenic concentration in surface water found in Nico Lake. The use of maximum concentrations of COPCs in environmental media may overestimate a receptors exposure to COPCs for the NICO Project. Furthermore, the maximum predicted soil, surface water, and sediment concentrations of all modelled NICO Project phases were used in the exposure assessment. The exposure point concentrations used in the WHRA are presented in Table 4.2-2.

Table 4.2-2: Exposure Point Concentrations for Environmental Media

Chemical	Maximum Concentration in Soil (mg/kg)	Phase[a]	Maximum Concentration in Sediment (mg/kg)	Phase[a]	Maximum Concentration in Surface Water (mg/L)	Phase[a]
Antimony	1.97	Closure	2.50	Closure	0.008	Post-Closure (Flooded Open Pit)
Arsenic	281	Closure	1090	Closure	0.27	Post-Closure (Flooded Open Pit)
Chromium	n/a	Closure	82.9	Closure	0.0020	Post-Closure (Nico Lake)
Copper	n/a	Closure	65.2	Closure	0.0120	Post-Closure (Flooded Open Pit)
Lead	n/a	Closure	12	Closure	0.0018	Post-Closure (Nico Lake)
Molybdenum	n/a	Closure	12.2	Closure	0.0152	Post-Closure (Flooded Open Pit)
Selenium	1.35	Closure	1.02	Closure	0.0071	Post-Closure (Flooded Open Pit)
Vanadium	29.15	Closure	71.9	Closure	0.0032	Post-Closure (Flooded Open Pit)
Zinc	n/a	Closure	189	Closure	0.0558	Post-Closure (Flooded Open Pit)

[a] Phase of the NICO Project when the maximum predicted soil, sediment, or surface water concentration is predicted to occur.
mg/kg = milligram per kilogram; mg/L = milligram per litre

4.2.3 Dietary Intake Assumptions

The estimate of exposure to COPCs also required assumptions with respect to dietary intake, including dietary preferences and the estimation of COPC concentrations in dietary items (i.e., vegetation and prey), including the uptake equations used to estimate COPC concentrations in dietary items. Estimates of dietary preferences and the uptake equations used to estimate COPC concentrations in dietary items were obtained from the literature, field data, and professional judgement.

4.2.3.1 Dietary Preferences

Dietary preferences for the receptors assessed in this study were intended to represent generic feeding guilds (e.g., herbivores, insectivores, omnivores, carnivores) as opposed to an assessment of the site-specific feeding behaviour of any individual species. Furthermore, to reduce the uncertainty in the WHRA, the selected herbivorous receptors were assumed to eat vegetation sampled in the region, if appropriate. With the exception of caribou, herbivorous wildlife was assumed to eat sedge. Caribou was assumed to eat lichen. The black bear which is an omnivore, was assumed to eat berries. Other vegetation types were sampled in the region (e.g., emergents, willow, alder, and paper birch); however, these vegetation types were not used in the assessment. The dietary preferences used in the WHRA for the selected receptors are shown in Table 4.2-3.

Table 4.2-3: Dietary Preferences

Receptor	Dietary Preference
Arctic ground squirrel	Sedge
Black bear	Berries, insects, small mammals
Caribou (Barren-ground and Woodland)	Lichen
Moose	Sedge
Muskrat	Sedge
Snowshoe hare	Sedge
Wolverine	Small mammals
Common nighthawk	Insects
Loon	Fish
Mallard	Sedge and insects
Olive-sided flycatcher	Flying insects
Peregrine falcon	Small mammals
Willow ptarmigan	Sedge
Rusty blackbird	Insects
Short-eared owl	Small mammals

4.2.3.2 Uptake Equations

The uptake equations used to estimate chemical concentrations in dietary items (i.e., earthworms and small mammals) were those used by the US EPA in the development of the Eco-SSLs (US EPA 2005a) (Table 4.2.4). There are no uptake equations for insects; therefore, the uptake equations derived for uptake into earthworms were used to estimate COPC concentrations in insects. This is a conservative approach in that uptake into earthworms assumes direct contact with soil. The insects consumed by receptors assessed in the WHRA may not be soil dwelling and the earthworm uptake equations may over-estimate COPC concentrations in insects.

Table 4.2-4: Uptake Equations for Estimating Chemical Concentrations in Dietary Items

Chemical	Soil to Sedge[a]	Soil to Lichen[a]	Soil to Berries[a]	Soil to Insects[b,c]	Soil to Mammals[b,d]	Surface Water to Fish[a]
Antimony	Cse = Cs * 0.04	Cl = Cs * 0.08	Cb = Cs * 0.01	Ce = Cs	Cm = 0.001*50*Ce	Cf = Cw * 16
Arsenic	Cse = Cs * 0.09	Cl = Cs * 0.09	Cb = Cs*0.004	ln(Ce) = 0.706*ln(Cs) - 1.421	ln(Cm) = 0.8188 * ln(Cs) - 4.8471	Cf = Cw * 73
Chromium	Cse = Cs * 0.12	Cl = Cs * 0.06	Cb = Cs * 0.03	Ce = 0.306*Cs	ln(Cm) = 0.7338*ln(Cs)-1.4599	Cf = Cw * 990
Copper	Cse = Cs * 0.18	Cl = Cs * 0.15	Cb = Cs * 0.22	Ce = 0.515*Cs	ln(Cm) = 0.144*ln(Cs)+2.042	Cf = Cw * 588
Lead	Cse = Cs * 0.09	Cl = Cs * 0.17	Cb = Cs * 0.01	ln(Ce) = 0.807*ln(Cs)-0.218	ln(Cm) = 0.4422*ln(Cs)+0.0761	Cf = Cw * 60
Molybdenum	Cse = Cs * 0.26	Cl = Cs * 0.07	Cb = Cs * 0.23	Ce = Cs	Cm - 0.006*50*Ce	Cf = Cw * 18
Selenium	Cse = Cs * 0.16	Cl = Cs * 0.27	Cb = Cs * 0.41	ln(Ce) = 0.733*ln(Cs)-0.075	ln(Cm) = 0.3764*ln(Cs)-0.4158	Cf = Cw * 902
Vanadium	Cse = Cs * 0.07	Cl = Cs * 0.06	Cb = Cs*0.004	Ce = 0.042*Cs	Cm = 0.0123*Cs	Cf = Cw * 83
Zinc	Cse = Cs * 0.93	Cl = Cs * 0.73	Cb = Cs * 0.35	ln(Cs) = 0.328*ln(Cs)+4.449	ln(Cm) = 0.0706*ln(Cs)+4.3632	Cf = Cw * 7807

[a] Uptake factors were calculated based on measured baseline media (soil and surface water) and tissue (plant and fish) concentrations.

[b] US EPA 2005a unless otherwise noted. The equations provided based on uptake into earthworms were conservatively applied to insects.

[c] For molybdenum, the US EPA does not provide an uptake equation for earthworms. As such, concentrations in insects were conservatively assumed to be equivalent to concentrations in soil.

[d] For molybdenum, the uptake equation provided was derived from F_f and IR values provided in Baes et al. (1984) and the equation provided in US EPA 2005a ($BAF_{soil\text{-}to\text{-}beef} = BAF_{soil\text{-}to\text{-}diet} * IR * F_f$); IR = ingestion rate = 50 kg wet weight food/day; F_f = ingestion-to-beef transfer coefficient (chemical specific as provided in Baes et al. 1984) (d/kg wet weight).

Cse = concentration in sedge (mg/kg dw); Cs = concentration in soil (mg/kg dw); Cl = concentration in lichen (mg/kg dw); Cb = concentration in berries (mg/kg dw); Ce = concentration in earthworm (insects) (mg/kg dw); Cm = concentration in mammals (mg/kg dw); Cf = concentration in fish (mg/kg ww); Cw = concentration in surface water (mg/L).

Uptake of COPCs into plants and fish was estimated using site-specific uptake factors and predicted concentrations in soil and surface water. The site-specific uptake factors were calculated from measured baseline data, specifically the average measured baseline concentrations in plants, fish, soil, and water were used in the calculation. Equation 3 was used to calculate the plant and fish uptake factors.

$$UF = \frac{C_T}{C_M} \qquad \textbf{(3)}$$

Where:
UF = Uptake Factor (unitless)
C_T = Baseline tissue concentration (plant or fish) (mg/kg dw for plants; mg/kg ww for fish)
C_M = Baseline media concentration (soil or water) (mg/kg for soil or mg/L for water)

Paired soil and plant data were used to derive the plant uptake factors. Paired data was available for both sedge and lichen and species-specific uptake factors were calculated. The measured baseline data was obtained from the soil and vegetation chemistry (Annex I of the DAR) and aquatic baseline reports (Annex C of the DAR).

In turn, the calculated uptake factors were used to estimate predicted chemical concentrations in plants and fish via simple rearrangement of equation 3.

$$C_T = UF \times C_M \qquad \textbf{(4)}$$

Where:
UF = Uptake Factor (unitless)
C_T = Predicted tissue concentration (plant or fish) (mg/kg dw for plants; mg/kg ww for fish)
C_M = Predicted media concentration (soil or water) (mg/kg for soil or mg/L for water)

Using the simple uptake factor, above, to estimate plant and fish tissue concentrations based on the maximum predicted soil and surface water concentrations is a conservative approach. Equations 3 and 4 assume a linear relationship between media concentrations (soil or surface water) and tissue concentrations (plants or fish) and likely over-estimates tissue concentrations. For example, for fish, the equation does not consider increased excretion from the fish at higher exposure concentrations. Nevertheless, this conservative approach was used in the WHRA.

4.2.3.3 Estimated Dietary Concentrations

The estimated chemical concentrations in dietary items are provided in Table 4.2-5.

Table 4.2-5: Estimated Chemical Concentrations in Dietary Items

Chemical	Concentration in Sedge (mg/kg dw)	Concentration in Lichen (mg/kg dw)	Concentration in Berries (mg/kg dw)	Concentration in Insects (mg/kg dw)	Concentration in Mammals (mg/kg dw)	Concentration in Fish (mg/kg ww)
Antimony	0.07	0.16	0.02	1.97	0.10	0.13
Arsenic	26.44	26.64	1.09	12.93	0.79	19.69
Chromium	2.77	1.27	0.66	7.00	2.31	1.95
Copper	28.93	24.16	34.21	81.82	16.02	7.05
Lead	0.63	1.25	0.08	4.03	2.61	0.11
Molybdenum	0.74	0.20	0.67	0.00	0.00	0.27
Selenium	0.22	0.37	0.55	1.16	0.74	6.44
Vanadium	2.00	1.81	0.11	1.22	0.36	0.26
Zinc	50.32	39.32	19.16	0.04	104.06	435.64

mg/kg = milligram per kilogram

4.2.4 Exposure Parameters

Subsequent to determining concentrations of COPCs in environmental media and dietary items, exposure probabilities, and diet preferences, the body weights and ingestion rates (soil, sediment, food, and water) for wildlife species must be estimated to calculate total exposure in terms of an EDI. The allometric equations provided in the Wildlife Exposure Factors Handbook (US EPA 1993) were used to calculate ingestion rates for receptors based on their respective body weights (Table 4.2-6). Body weights were obtained from the literature (Table 4.2-7). The ingestion rates calculated using the allometric equations as well as other exposure parameters used in the assessment are provided in Table 4.2-7.

Table 4.2-6: Allometric Equations Used to Calculate Food and Water Ingestion Rates

Ingestion Rate	Allometric Equation[a]	Units[b]
Food ingestion rate non-rodent	$=0.0687(BW)^{0.822}$	kg dw/day
Food ingestion rate rodent	$=0.621(BW)^{0.564}$	g dw/day
Food ingestion rate passerines	$=0.398(BW)^{0.850}$	g dw/day
Food ingestion rate non-passerines	$=0.301(BW)^{0.751}$	g dw/day
Water ingestion rate mammals	$=0.099(BW)^{0.90}$	L/day
Water ingestion rate birds	$=0.059(BW)^{0.67}$	L/day

[a] US EPA (1993).

[b] The allometric equations provide ingestion rates on a dry weight (dw) basis.

BW = Body weight; L/day = litre per day

Table 4.2-7: Exposure Parameters for Mammals

Exposure Parameter	Units	Arctic Ground Squirrel	Black Bear	Caribou	Moose	Muskrat	Snowshoe Hare	Wolverine
BW	kg	0.7[a]	76.2[b]	100[c]	600[d]	1.3[e]	1.5[b]	13[f]
Proportion of Soil	%	6.3[g]	2.8[g]	20[h]	2[i]	3.3[g]	6.3[g]	2.8[g]
Proportion of Plants	%	100[k]	85[j]	100[k]	100[k]	100[k]	100[k]	0[k]
Proportion of Insects	%	0[k]	10[j]	0[k]	0[k]	0[k]	0[k]	0[k]
Proportion of Mammals	%	0[k]	5[j]	0[k]	0[k]	0[k]	0[k]	100[k]
Proportion of Fish	%	0[k]	0[k]	0k	0[k]	0[k]	0[k]	0[k]
Food IR	kg dw/d	0.02	2.42	3.03	13.20[e]	0.04	0.04	0.57
Soil IR	kg dw/d	0.002	0.07	0.61	0	0	0.002	0.02
Sediment IR	kg dw/d	0	0	0	0.26	0.001	0	0
Water IR	kg/d	0.07	4.89	6.25	31.33[e]	0.13[e]	0.14	1.00
Plant IR	kg dw/d	0.02	2.06	3.03	13.20	0.04	0.04	0
Worm IR	kg dw/d	0	0.24	0	0	0	0	0
Mammal IR	kg dw/d	0	0.12	0	0	0	0	0.57
Fish IR	kg dw/d	0	0	0	0	0	0	0

[a] Government of Nunavut (2011, internet site).

[b] Harestad and Bunnell (1979).

[c] Alaska Department of Fish and Game (2011, internet site).

[d] Telfer (1997, internet site).

[e] US EPA (1993).

[f] Banci (2001, internet site).

[g] Kroner and Cozzie (1999).

[h] MacDonald and Gunn (2004).

[i] Beyer et al. (1994).

[j] Hellgren 1993.

[k] Assumed

kg dw/d = kilograms dry weight/day; BW = Body weight; IR = Ingestion rate' % = percent

Table 4.2-8: Exposure Parameters for Birds

Exposure Parameter	Units	Common Nighthawk	Loon	Mallard	Olive-Sided Flycatcher	Peregrine Falcon	Willow Ptarmigan	Rusty Blackbird	Short-Eared Owl
BW	kg	0.065[a]	2.2[b]	1[c]	0.032[d]	0.57[e]	0.5[f]	0.064[g]	0.315[h]
Proportion of Soil	%	1[i]	3.3[j]	3.3[j]	1[i]	1[i]	9.3[i]	0[i]	1[i]
Proportion of Plants	%	0[m]	0[m]	25[k]	0[m]	0[m]	100	36.7[l]	0[m]
Proportion of Insects	%	100[m]	0[m]	75[k]	100[m]	0[m]	0[m]	63.3[l]	0[m]
Proportion of Mammals	%	0[m]	0[m]	0[m]	0[m]	100	0[m]	0[m]	100[m]
Proportion of Fish	%	0[m]	100[m]	0[m]	0[m]	0[m]	0[m]	0[m]	0[m]
Food IR	kg dw/d	0.01	0.10	0.05	0.008	0.04	0.03	0.01	0.02
Soil IR	kg dw/d	0.0001	0.003	0.002	0.0001	0.0004	0.003	0.0001	0.0002
Sediment IR	kg dw/d	0	0.003	0.002	0	0	0	0	0
Water IR	kg/d	0.01	0.10	0.06	0.006	0.04	0.04	0.009	0.03
Plant IR	kg dw/d	0	0	0.01	0	0	0.03	0.005	0
Worm IR	kg dw/d	0.01	0	0.04	0.008	0	0	0.009	0
Mammal IR	kg dw/d	0	0	0	0	0.04	0	0	0.02
Fish IR	kg dw/d	0	0.10	0	0	0	0	0	0

[a] COSEWIC (2007b).
[b] Evers et al. (2010, internet site).
[c] Drilling (2002, internet site).
[d] Altman and Sallabanks (2000, internet site).
[e] Blood (2006, internet site).
[f] Aniskowics (1994, internet site).
[g] COSEWIC (2006).
[h] Wiggins et al. (2006, internet site).
[i] Kroner and Cozzie (1999).
[j] Beyer et al. (1994).
[k] US EPA (1993).
[l] Sample et al. (1997).
[m] Assumed
kg dw/d = kilograms dry weight/day; BW = Body weight; IR = Ingestion rate; % = percent

The soil ingestion rate for caribou was assumed to be equal to 20% of the food ingestion rate. This is based on a study by MacDonald and Gunn (2004) that analysed the elemental composition of caribou fecal pellets at the Colomac Gold Mine in the NWT. They hypothesised that the increased soil ingestion rate for caribou relative to other ungulates is due to the ingestion of tailings. Caribou are attracted to the tailings due to their high mineral composition and the caribou's need to acquire minerals, particularly sodium, to replace low levels in spring caused by reproductive demands and the use of low-mineral foods over the winter (MacDonald and Gunn 2004). Caribou exposure to tailings at the NICO Project is not considered to be a relevant pathway as during operations, the CDF, where the tailings will be placed, will not provide suitable habitat or be attractive to wildlife receptors due to the increased mining activities and noise disturbance. Once mining operations are complete, the tailings in the CDF will be capped to prevent further exposure. Although direct exposure to tailings is not anticipated, the soil ingestion rate measured by MacDonald and Gunn (2004) was used to estimate caribou exposure to maximum soil concentrations of COPCs for the NICO Project.

4.2.5 Exposure Estimate Calculation

4.2.5.1 Equations

For the COPCs evaluated in the WHRA, exposure via ingestion of soil/sediment, water and food was calculated based on a daily dose or intake (i.e., an EDI). Therefore, exposures were estimated on a body weight basis (i.e., x mg chemical/kg body weight/day) using specific equations (Table 4.2-9).

Table 4.2-9: Exposure Equations

Pathway	Equation and Equation Parameters
Water ingestion	$EDI_{water} = \frac{IR \times C_{water}}{BW}$
	EDI_{water} = exposure due to ingestion of water (mg COPC/kg body weight/day) IR = ingestion rate (L/day) C_{water} = COPC concentration in water (mg/L) BW = receptor body weight (kg)
Soil ingestion	$EDI_{soil} = \frac{IR \times C_{soil}}{BW}$
	EDI_{soil} = exposure due to ingestion of soil (mg COPC/kg body weight/day) IR = ingestion rate (kg/day) C_{soil} = COPC concentration in soil (mg/kg) BW = receptor body weight (kg)
Plant ingestion	$EDI_{plant} = \frac{IR \times C_{plant}}{BW}$
	EDI_{plant} = exposure due to ingestion of plant (mg COPC/kg body weight/day) IR = ingestion rate (kg dw/day) C_{plant} = COPC concentration in plant (mg/kg dw) BW = receptor body weight (kg)
Prey ingestion (i.e., mammals, fish)	$EDI_{prey} = \frac{IR \times C_{prey}}{BW}$
	EDI_{prey} = exposure due to ingestion of prey (mg COPC/kg body weight/day) IR = ingestion rate (kg dw/day) C_{prey} = COPC concentration in prey (mg/kg dw) BW = receptor body weight (kg)

The total estimated exposure to a COPC was calculated using equation 5.

$$Exp = \Sigma EDI \times P_{Exp} \quad \textit{(5)}$$

Where:
Exp = Total exposure due to ingestion (mg COPC/kg body weight/day)
ΣEDI = Sum of the EDIs for all ingestion pathways assessed (mg COPC/kg body weight/day)
P_{Exp} = Probability of exposure from the NICO Project area (unitless)

It should be noted that the estimated COPC concentrations in fish tissues were converted from a ww basis to a dw basis using a percent moisture content of 75% (Sample and Suter 1994) before being used in equation 5.

4.2.5.2 Exposure Estimates

The calculated total exposures due to ingestion for the receptors assessed in the WHRA are presented in Tables 4.2-10 and 4.2-11.

Table 4.2-10: Total Exposure Due to Ingestion for Mammals

Chemical	Arctic Ground Squirrel (mg/kg-day)	Black Bear (mg/kg-day)	Caribou (mg/kg-day)	Moose (mg/kg-day)	Muskrat (mg/kg-day)	Snowshoe Hare (mg/kg day)	Wolverine (mg/kg-day)
Antimony	0.01	0.002	0.0000005	0.0003	0.01	0.01	0.001
Arsenic	1.60	0.07	0.0001	0.09	1.73	1.16	0.06
Chromium	n/a	n/a	n/a	0.01	0.15	n/a	n/a
Molybdenum	n/a	n/a	n/a	0.002	0.03	n/a	n/a
Selenium	0.01	0.004	0.000001	0.0005	0.01	0.01	0.005
Zinc	n/a	n/a	n/a	0.10	1.55	n/a	n/a

n/a = not applicable (only identified as a COPC in sediment); mg/kg-day = milligram per kilogram per day

Table 4.2-11: Total Exposure Due to Ingestion for Birds

Chemical	Common Nighthawk (mg/kg-day)	Loon (mg/kg-day)	Mallard (mg/kg-day)	Olive-Sided Flycatcher (mg/kg-day)	Peregrine Falcon (mg/kg-day)	Willow Ptarmigan (mg/kg-day)	Rusty Blackbird (mg/kg-day)	Short-Eared Owl (mg/kg-day)
Antimony	0.42	0.03	0.09	0.47	0.00	0.02	0.28	0.01
Arsenic	3.39	5.50	3.33	3.78	0.01	3.39	4.45	0.28
Chromium	n/a	0.50	0.51	n/a	n/a	n/a	n/a	n/a
Copper	n/a	1.58	4.10	n/a	n/a	n/a	n/a	n/a
Lead	n/a	0.05	0.21	n/a	n/a	n/a	n/a	n/a
Molybdenum	n/a	0.07	0.15	n/a	n/a	n/a	n/a	n/a
Selenium	0.25	1.15	0.05	0.28	0.002	0.02	0.61	0.05
Vanadium	0.32	0.19	0.26	0.36	0.002	0.30	0.38	0.05
Zinc	n/a	77.54	1.12	n/a	n/a	n/a	n/a	n/a

n/a = not applicable (only identified as a COPC in sediment); mg/kg-day = milligram per kilogram per day

4.2.5.3 Bioavailability

In the WHRA, exposure estimates were not adjusted for bioavailability because TRVs were expressed as the administered dose (i.e., amount taken into the body), rather than the absorbed dose (i.e., amount absorbed and retained in the body). This is a conservative approach because the administered dose is often in a more bioavailable form than that that is found in the environment (e.g., lead acetate in the laboratory versus lead phosphate in the environment). Not taking bioavailability into account in the exposure assessment may over estimate risks to wildlife receptors.

4.3 Toxicity Assessment

Toxicity assessment involves identification of the potentially toxic effects of a chemical and determination of the dose to which a receptor can be exposed without experiencing adverse health effects. The dose of a chemical that does not result in adverse health effects is defined as the TRV. The following sources of information were used for determination of TRVs for the WHRA, in order of priority:

- US EPA Eco-SSLs;
- Oak Ridge National Laboratory Toxicity Benchmarks for Wildlife;
- US EPA's Integrated Risk Information System;
- Agency for Toxic Substances and Disease Registry; and
- in cases where no regulatory agency provided a TRV, values from peer-reviewed sources from the scientific literature were used.

The TRVs selected for the WHRA were based on reproductive, growth or developmental endpoints. No Observed Adverse Effect Levels (NOAEL) were used to evaluate receptors identified as SAR (wolverine, rusty blackbird, peregrine falcon, olive-sided flycatcher, short-eared owl, common nighthawk) and Lowest Observed Adverse Effect Levels (LOAEL) were used to evaluate all other receptors. The use of NOAELs based on reproductive, growth or developmental endpoints as toxicological benchmarks for identified SAR is considered an appropriate approach as impairment of individuals could imperil populations. However, the exceedance of a NOAEL does not necessarily indicate that adverse health effects to populations will actually occur as these benchmarks are based on laboratory studies where laboratory animals are often administered a dose of a chemical that is in a more available form (i.e., easily adsorbed by the body) than it would be in the natural environment. Further discussion on bioavailability is provided in Section 4.2.5.3. The basis on which the selected TRVs were derived is provided in Appendix C (Tables C-1 and C-2 for mammals and birds, respectively). The TRVs used in the WHRA for mammals and birds are summarized in Table 4.3-1.

Table 4.3-1: Toxicity Reference Values for Wildlife

Chemical	Mammals				Birds			
	NOAEL (mg/kg-day)	Source	LOAEL (mg/kg-day)	Source	NOAEL (mg/kg-day)	Source	LOAEL (mg/kg-day)	Source
Antimony	0.125	a	1.25	a	NV	-	NV	-
Arsenic	0.126	a	1.26	a	2.24	b	12.84	a
Chromium	2.40	b	NV	-	2.66	b	5	a
Copper	n/a	-	n/a	-	4.05	b	61.7	a
Lead	n/a	-	n/a	-	1.63	b	11.3	a
Molybdenum	0.26	a	2.6	a	3.5	a	35.3	a
Selenium	0.143	b	0.33	a	0.290	b	0.8	a
Vanadium	n/a	-	n/a	-	0.344	b	0.688	c
Zinc	75.4	b	320	a	66.1	b	131	a

[a] Sample et al. (1996).

[b] US EPA (2010, internet site).

[c] Hill (1979).

n/a = Not applicable; NV = No value; mg/kg-day = milligram per kilogram per day

4.4 Risk Characterization

4.4.1 Approach

Risk characterization is the final component in the RA process, during which the exposure and toxicity assessments are integrated. Exposure Ratios (ERs) were calculated as the ratio of the predicted total exposure to the TRV (equation 6):

$$ER = \frac{Exp}{TRV} \quad \textbf{\textit{(6)}}$$

Where:
ER = Exposure Ratio (unitless)
Exp = Total exposure due to ingestion (mg /kg-day)
TRV = Toxicity reference value (mg/kg-day)

The standard ER threshold for evaluation is 1. That is, an ER value of equal to or less than 1 indicates that the level of exposure in the environment is less than the level of exposure shown to adversely affect the health of a receptor. Therefore, the level of exposure should not pose a health risk to wildlife health. As a result, populations of wildlife are also not at unacceptable risk. An ER value greater than 1 indicates that the level of exposure in the environment may exceed a level where adverse effects on the receptor may occur.

The ERs were calculated using exposures based on maximum COPC concentrations from the predicted worst case phase of the NICO Project. For soils and sediment, the predicted worst case phase of the NICO Project was at closure and for surface water, the predicted worst case phase of the NICO Project was at post-closure (Table 4.2-2). Soil and sediment concentrations increase as the operations phase progresses. However, once the operation phase is complete, the associated dust generation and metals deposition to soil and surface water will cease and soil and sediment concentrations will decrease over time as new soil/sediment accumulates. Ultimately background levels in soil and sediment will be reached.

Maximum surface water concentrations occur at post-closure. However, during closure and post-closure water that accumulates in SCP Nos. 1, 2, 3, and 5, as well as the Surge Pond will be passively treated in Wetland Treatment Systems (No. 1 to 3) and then released directly into Nico Lake. This is subject to the demonstration of the technical performance of the Wetland Treatment Systems. If the technical performance of the Wetland Treatment Systems is not demonstrated prior to closure, then the contingency will be to pump water from SCP Nos. 1, 2 3, and 5, as well as from the Surge Pond, into the Open Pit. Initially, water will accumulate in the Open Pit. Just prior to pit overflow, the water quality at the top of the Flooded Open Pit will be evaluated, and a decision will be made about post-overflow treatment. Therefore, if unacceptable wildlife health risks are not calculated for these worst case scenarios, it can be assumed that unacceptable wildlife health risks will not be present during the other phases (i.e., construction and operations phases) of the NICO Project.

Based on the magnitude of calculated ERs, risks were categorized as follows:

- Negligible risk: ER less than or equal to 1. This conclusion is consistent with standard practice in RA.
- Low risk and likely to be negligible: ER greater than 1 but less than or equal to 10. This conclusion is generally true but should be reviewed on a chemical-specific basis, as the conservatism of the analysis varies dependent on a number of factors used in the assessment.
- Potentially elevated risk: ER greater than 10; adverse effects are possible due to the chemical in questions.

Exposure ratios of less than 1 suggest that a receptor is not at risk, while ERs of greater than 1 suggest a receptor may be at risk. Chemicals with ERs greater than 1 were further assessed in a magnitude of effect assessment to determine whether they are truly of concern. This assessment considered the following:

- Comparison of the ERs for upper bound and central-tendency estimates;
- Comparison of Project Case ERs to Baseline Case ERs;
- Evaluation of the conservatism in the exposure estimates; and
- Evaluation of the conservatism in the TRV for the COPC.

4.4.2 Risk Estimates

The calculated ERs for the receptors assessed in the WHRA are presented in Tables 4.4-1 and 4.4-2.

Table 4.4-1: Exposure Ratios for Mammals

Chemical	Arctic Ground Squirrel	Black Bear	Caribou	Moose	Muskrat	Snowshoe Hare	Wolverine
Antimony	0.006	0.001	0.000004	0.0002	0.004	0.005	0.0008
Arsenic	**1.27**	0.05	0.0005	0.07	**1.37**	0.92	0.05
Chromium	n/a	n/a	n/a	0.004	0.06	n/a	n/a
Molybdenum	n/a	n/a	n/a	0.0007	0.01	n/a	n/a
Selenium	0.04	0.01	0.000004	0.001	0.02	0.03	0.01
Zinc	n/a	n/a	n/a	0.0003	0.005	n/a	n/a

n/a = Not applicable. The chemical was only identified as a COPC in sediment; NV = No value; Shaded + bold text = exposure ratio greater than 1.

Table 4.4-2: Exposure Ratios for Birds

Chemical	Common Nighthawk	Loon	Mallard	Olive-Sided Flycatcher	Peregrine Falcon	Willow Ptarmigan	Rusty Blackbird	Short-Eared Owl
Antimony	NV	NV	NV	NV	NV	NV	NV	NV
Arsenic	**1.51**	0.43	0.26	**1.69**	0.00	0.26	**1.99**	0.13
Chromium	n/a	0.10	0.1	n/a	n/a	n/a	n/a	n/a
Copper	n/a	0.03	0.07	n/a	n/a	n/a	n/a	n/a
Lead	n/a	0.004	0.02	n/a	n/a	n/a	n/a	n/a
Molybdenum	n/a	0.002	0.004	n/a	n/a	n/a	n/a	n/a
Selenium	0.86	**1.43**	0.07	0.96	0.007	0.03	0.61	0.19
Vanadium	0.94	0.56	0.75	**1.04**	0.005	0.88	**1.12**	0.14
Zinc	n/a	0.59	0.009	n/a	n/a	n/a	n/a	n/a

n/a = Not applicable. The chemical was only identified as a COPC in sediment; NV = No value; Shaded + bold text = exposure ratio greater than 1.

The Arctic ground squirrel, muskrat, common nighthawk, olive-sided flycatcher, and rusty blackbird had calculated ERs greater than 1 for arsenic. An exposure ratio of greater than 1 was also calculated for exposure to vanadium for the olive-sided flycatcher and rusty blackbird and for exposure to selenium for the loon. The ERs calculated are only slightly greater than 1, and based on the conservative assumptions used in the WHRA, likely represent only a marginal risk. An ER value of greater than 1 indicates that there is a potential for adverse effects. However, ER values greater than 1 do not necessarily indicate that adverse health effects to populations will actually occur due to the layers of safety employed in their estimation. Furthermore, an ER of greater than 1 for wildlife does not mean that there will be discernible effects for a population. For the COPCs with ERs greater than one (i.e., arsenic, selenium, and vanadium), a magnitude of effect assessment was performed to determine if the NICO Project has a negligible, low, moderate for high effect on the potential for unacceptable risk to wildlife, as detailed in the following section.

4.4.3 Magnitude of Effect Assessment

As indicated previously, risks are considered to be low and likely to be negligible when ER values are greater than 1 but less than or equal to 10. This conclusion is generally true but should be reviewed on a chemical-specific basis, as the conservatism of the analysis varies dependent on a number of factors used in the assessment. For the COPCs with ERs greater than one (i.e., arsenic, selenium, and vanadium), a magnitude of effect assessment was performed to determine if the NICO Project has a negligible, low, moderate for high effect on the potential for unacceptable risk to wildlife, as detailed in the following sections. The following sections describe some of the uncertainties associated with the assessment. Collectively, these assumptions weight heavily towards ERs that overestimate the actual risk to wildlife that is due to the NICO Project.

4.4.3.1 Comparison of Upper Bound and Central Tendency Estimates

It was assumed that wildlife receptors would be exposed to the maximum predicted COPC concentrations in the NICO Project area. This is a conservative assumption that likely overestimates receptor exposure as predicted concentrations in soils vary across the NICO Project area and predicted concentrations in sediment and surface water vary from lake to lake. It was also assumed that a receptor would be exposed to the maximum predicted concentration of a COPC in all media. That is, it was assumed that the receptor would be exposed to soil at the MPOI for particulate deposition, as well as surface water in the Flooded Open Pit or Nico Lake. This too is a conservative assumption in that, for example, the maximum concentration of arsenic in soil predicted at the MPOI may not be adjacent to the maximum arsenic concentration in surface water predicted for the Flooded Open Pit or Nico Lake.

Given that the use of maximum concentrations of COPCs in environmental media may overestimate a receptors exposure to COPCs for the NICO Project, the ERs calculated based on the upper-bound estimate of COPC concentrations in environmental media (i.e., maximum predicted concentrations) were compared to ERs calculated based on a central tendency estimate of COPC concentrations in environmental media (i.e., average predicted concentrations in soil and median predicted concentrations in sediments). It should be noted that for arsenic, selenium, and vanadium, ER calculations were performed based on predicted concentrations in surface water for the Flooded Open Pit, which is where the worst-case predicted water quality occurs. Only maximum water quality predictions were provided, and as such, a central-tendency estimate of COPC concentrations cannot be used for surface water. Still, based on central tendency estimates of concentrations in all other media, ERs for arsenic for the Arctic ground squirrel and muskrat were 0.88 and 0.73, respectively, below the target ER of 1. For birds, ERs slightly exceed the target ER of 1. The ERs for arsenic were 1.15 for the common nighthawk, 1.28 for the olive-sided flycatcher, and 1.27 for the rusty blackbird. The ER for selenium was 1.43 for the loon and the ER value for vanadium was 1.04 for the olive-sided flycatcher and 0.95 for the rusty blackbird.

4.4.3.2 Comparison of Baseline Case and Project Case Exposure Ratios

Using average measured baseline concentrations in all environmental media (i.e., soil, sediment and surface water) Baseline Case ERs were calculated to compare with the calculated NICO Project Case ERs. The ERs for arsenic for the Arctic ground squirrel and muskrat were 0.68 and 0.66, respectively, within a factor of 2 of the NICO Project Case ERs (Table 4.4-1). For birds, the Baseline Case ERs for arsenic were 0.94, 1.05, and 1.15 for the common nighthawk, olive-sided flycatcher, and rusty blackbird, within a factor of 2 of the NICO Project Case ERs. As well, under baseline conditions, there are exceedances of the target ER of 1 for the olive-sided flycatcher (ER=1.05) and the rusty blackbird (ER=1.01), suggesting that the TRVs used in the calculation are conservative for the NICO Project area. The Baseline Case ER for selenium for the loon was 0.06, approximately 20 times less than the NICO Project ER of 1.43. Still, average measured baseline concentrations were used in the calculation. If maximum measured concentrations in the Baseline Case are used in the calculation, an ER of approximately 100 is calculated for the loon, again suggesting that the TRV used in the calculation for selenium for birds is conservative for the NICO Project area. The Baseline Case ER for vanadium for the olive-sided flycatcher was 0.91 and for the rusty blackbird was 0.98, within a factor of 2 of the NICO Project Case ER.

4.4.3.3 Conservatism in Exposure Estimates

A number of conservative assumptions were used in the calculation of exposure estimates. These primarily relate to the concentration assumptions used for environmental media (soil, sediment, and surface water), the assumptions used in the modelling of predicted soil, sediment, and surface concentrations and assumptions with respect to bioavailability.

As first described in Section 4.4.3.1, it was assumed that wildlife receptors would be exposed to the maximum predicted COPC concentrations in the NICO Project area. This is a conservative assumption that likely overestimates receptor exposure as predicted concentrations vary across the NICO Project area.

In themselves, the predicted soil, surface water, and sediment concentrations used in the assessment are conservative. For example, the dispersion models used in the air quality assessment (Section 10 of the DAR) simplify the atmospheric processes associated with air mass movement and turbulence. This simplification limits the capability of a model to replicate discrete events and therefore introduces uncertainty. As a result of the uncertainty, dispersion models, coupled with their model inputs, are generally designed to conservatively model concentration and deposition values, so that practitioners can apply model results with the understanding that effects are likely to be over-estimated. The following general comments are made with respect to air quality modelling results for the NICO Project:

- Parameterization of emissions from diffuse area sources is difficult to simulate in dispersion models. Modelled results near mine pits and other sources of mechanically generated particulates are most uncertain. Most estimates of particulate emissions for mining activities are based on US EPA emission factors. Many of these factors have limited applicability outside of the area in which they were developed (typically south-western United States coal mines). Based on experience, it is expected that emissions estimated using this approach would be conservative.
- The air quality and deposition rate predictions used the maximum emission rates from the NICO Project during construction and operations. Predicted annual deposition rates were based on the maximum of the

daily road dust emissions during summer and winter. This approach will result in conservative predictions of air quality and deposition rates.

- Emissions of road dust from on-site haul roads, the primary sources of particulate matter and metal compounds, do not include potential mitigating effects of weather (such as precipitation or snow-covered ground) which will result in an overestimate of annual air quality predictions and deposition rates.
- Geochemistry data used to estimate metal concentrations in dust included a large proportion of concentrations below the analytical detection limit for cadmium and selenium. Concentrations of these metals were set at the detection limit for air quality and deposition modelling.
- Based on a review of the particulate material monitoring data at the Snap Lake diamond mine, the elevated particulate matter deposition rates identified in this assessment are due in part to the conservative emission estimates.

The approach used to estimate incremental changes in concentrations of total suspended solids and metals in surface waters using the modelled deposition rates was also conservative because no retention of particulates or metals was assumed in lake watersheds (i.e., all deposited material was assumed to enter the lakes) (Section 7.0 of the DAR). As a result of these factors, predicted changes in total suspended solids and metal concentrations in lakes are considered to be conservative estimates of the maximum potential changes that could occur during construction and operations. As well, incremental changes in soil concentrations are considered to be conservative estimates as it was assumed that the soils would be accumulating COPCs at the maximum deposition rate every day for 21 years.

In the WHRA, exposure estimates were not adjusted for bioavailability because TRVs were expressed as the administered dose (i.e., amount taken into the body), rather than the absorbed dose (i.e., amount absorbed and retained in the body). This is a conservative approach because the administered dose is often in a more bioavailable form than that that is found in the environment (e.g., lead acetate in the laboratory versus lead phosphate in the environment). Not taking bioavailability into account in the exposure assessment may over estimate risks to wildlife receptors.

4.4.3.4 Conservatism in Toxicity Reference Values

The TRVs relied upon in the WHRA are based on controlled laboratory studies. In toxicity studies, laboratory animals are administered doses of chemicals (e.g., metals) in a highly bioavailable form. The bioavailable form of the metal is considered to be the toxic component as it is readily absorbed into the body. In the natural environment, the availability of metals from soils and sediment is not expected to be as high, because the metals are usually bound to the soil/sediment constituents, and are less bioavailable. As a result, receptors in the wild often can be exposed to greater concentrations of metals (calculated on a dose basis) than laboratory animals as the dose of the bioavailable fraction may actually be lower.

The TRV for arsenic provided by Sample et al. (1996) was used for mammals (including the Arctic ground squirrel and muskrat) in the assessment. This value is based on a study using water dosed with arsenite, which is likely more bioavailable than the form of arsenic found in the natural diet of the arctic ground squirrel and the muskrat (i.e., arsenic bound to soil/sediment or in food is likely less bioavailable than arsenic in water), which likely overestimates risks to these wildlife receptors.

The TRVs used by the US EPA in the derivation of the Eco-SSLs were used for the common nighthawk, olive-sided flycatcher, and rusty blackbird in the assessment. These values represent the geometric mean of NOAELs for reproduction and growth or the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth or mortality. These values represent the highest dose that did not cause any adverse effects in any test species and are considered to be moderately conservative (US EPA 2005a). As such, use of these values in the WHRA may overestimate risks to the common nighthawk, olive-sided flycatcher and rusty blackbird.

As indicated above, the ERs for the common nighthawk, olive-sided flycatcher and rusty blackbird were calculated using NOAEL-based TRVs. The ERs were re-calculated with effects threshold, or LOAEL-based, TRVs, and are presented in Table 4.4-3. The LOAEL is the concentration at which there is an actual, though marginal, risk of an adverse effect. Although the LOAEL is slightly less conservative than the NOAEL, it is still an appropriate benchmark to use to evaluate potential risks to the common nighthawk, olive-sided flycatcher, and rusty blackbird as exceedances of the LOAEL do not necessarily indicate that adverse health effects to populations will actually occur, but only that adverse effects to individuals may occur. The re-calculated ERs using the LOAELs are below 1.

Table 4.4-3: Exposure Ratios for Arsenic and Vanadium for Birds Using a Lowest Observed Adverse Effect Level-Based Toxicity Reference Value

Chemical	Common Nighthawk	Olive-Sided Flycatcher	Rusty Blackbird
Arsenic	0.3	0.3	0.3
Vanadium	n/a	0.5	n/a

n/a = Not applicable. The exposure ratio for this receptor and chemical was not greater than 1.

4.4.3.5 Summary of Magnitude of Effect Assessment

The risk of adverse health effects to mammals (Arctic ground squirrel and muskrat) and birds (common nighthawk, loon, olive-sided flycatcher, and rusty blackbird) with ERs greater than 1 is considered negligible based on the following:

- For the Project Case, ERs were slightly above 1 (but less than 2) based on upper-bound estimates of exposure (Arctic ground squirrel, muskrat, common nighthawk, loon, olive-sided flycatcher, and rusty blackbird) but were less than 1 based on central tendency estimates of exposure for some wildlife (Arctic ground squirrel and muskrat).
- ERs were slightly above 1 (but less than 2) for the Project Case but were within a factor of 2 of the Baseline Case for arsenic and vanadium.
- It was assumed that wildlife would be exposed to the maximum predicted COPC concentrations in the NICO Project area. This is a conservative assumption that likely overestimates exposure as predicted concentrations vary across the NICO Project area and receptors are unlikely to be exposed exclusively to the maximum concentrations.
- Various conservative assumptions are used in the predictive air, water, and sediment quality modelling such that exposure point concentrations used in the assessment likely overestimate exposure to wildlife.
- Exposure estimates were not adjusted for bioavailability which may overestimate exposure to wildlife.

- The TRVs used in the assessment are based on laboratory studies using metals in highly bioavailable forms. Use of these TRVs may overestimate risk to wildlife.
- The NOAEL-based TRVs used for birds are considered to be moderately conservative (US EPA 2005a) which may overestimate risk to wildlife.
- Use of LOAEL-based TRVs results in ER values of less than 1 for the common nighthawk, olive-sided flycatcher and rusty blackbird.

5.0 SUMMARY OF WILDLIFE HEALTH RESULTS AND CONCLUSIONS

Overall, based on the calculated ERs and the magnitude of effect assessment for chemicals with ERs greater than 1, the risk of adverse health effects to mammals and birds from the NICO Project is considered negligible based on the following (given that caribou are a KLOI for the NICO Project, they are addressed separately in Section 5.1):

- With the exceptions of arsenic, selenium, and vanadium, ERs are less than 1 for all COPCs, indicating negligible risk of adverse health effects to wildlife as a result of the NICO Project. The ERs were calculated using the maximum predicted COPC concentrations in soil, sediment, and surface water from the predicted worst-case phase of the NICO Project. The maximum predicted concentrations occur during closure for soil and sediment and during post-closure for surface water. Because there is negligible risk of adverse health effects to wildlife during these phases of the NICO Project, it can be assumed that risks are negligible during all other phases of the NICO Project when predicted concentrations of the COPCs are lower.
- The ERs were slightly above one (but less than 2) for arsenic (Arctic ground squirrel, muskrat, common nighthawk, olived-sided flycatcher, and rusty blackbird), selenium (loon) and vanadium (olive-sided flycatcher); however, further analysis of these chemicals indicated negligible risk of adverse effects to wildlife as a result of the NICO Project based on the numerous conservative assumptions used in the assessment that would overestimate exposure and risk to wildlife.

The effects of the NICO Project were considered in combination with other developments (current and foreseeable) that may also influence the health of wildlife in the NICO Project area. Of the foreseeable developments identified in the DAR (Section 6.5.2.4), none are expected to result in changes in water and sediment quality. The potential for cumulative effects from the Rayrock and Colomac mines to water quality was identified as a concern by the Tłı̨chǫ Government and citizens, and has been identified in the TOR (MVRB 2009). However, impacts to water quality are considered negligible downstream of Burke Lake (Section 7.0 of the DAR), and the risk of adverse effects to wildlife are also considered negligible. The former Rayrock Mine site is located at least 15 km downstream of Burke Lake, so the cumulative effects on water quality and subsequently wildlife are also considered negligible. The former Colomac Mine is located 120 km to the northeast in another drainage system (Section 7 of the DAR), which eliminates the potential for a cumulative effect to water quality and subsequently wildlife. This is with the exception of those wildlife species that are migratory or that have large home ranges that may spend time in the vicinity of the former mine sites. However, with the conservative assumptions used in the exposure assessment and toxicity assessment, the ERs calculated for those species that may spend time at other sites (i.e., black bear, moose, wolverine, peregrine falcon) are orders of magnitude less than the benchmark of 1. Therefore, the potential for a cumulative effect on wildlife health is considered to be negligible.

For air quality, the RSA for the air quality assessment was selected to include air quality cumulative effects associated with emissions for existing and approved industrial sources within the region, including the former Rayrock mine in combination with the NICO Project (Section 10 of the DAR). As such, with respect to emissions to air, potential cumulative effects on wildlife health have been captured in the WHRA. Based on the above, the risk of adverse health effects to wildlife from the NICO Project and other developments in the region (current and foreseeable; i.e., the Cumulative Effects Case) is considered negligible given that the risk of adverse health effects to wildlife for the NICO Project are considered negligible.

5.1 Caribou Health Results and Conclusions

Caribou are of special concern to First Nations, and caribou have been identified as a KLOI in the TOR for the NICO Project (MVRB 2009). There is particular concern with caribou's exposure to tailings and increased uptake of COPCs from the tailings. MacDonald and Gunn (2004) suggest that caribou are attracted to the tailings due to their high mineral composition, and the caribou's need to acquire minerals, particularly sodium, to replace low levels in spring caused by reproductive demands and the use of low-mineral foods over the winter. They suggest that the caribou soil ingestion rate can be equal to 20% of food ingestion. Caribou exposure to tailings at the NICO Project is not considered to be a relevant pathway as during operations, the CDF, where the tailings will be placed, will not provide suitable habitat or be attractive to wildlife receptors due to the increased mining activities and noise disturbance. Once mining operations are complete, the tailings in the CDF will be capped to prevent further exposure.

Although direct exposure to tailings is not anticipated, the elevated soil ingestion rate associated with the ingestion of tailings was used to estimate caribou exposure to maximum soil concentrations of COPCs at the NICO Project. Using the elevated soil ingestion rates, unacceptable risks to caribou as a result of chemical exposure from the NICO Project are not anticipated, based on the calculated ERs (ERs are less than 1). As such, the risk of adverse health effects to caribou from the NICO Project is considered negligible.

The caribou occupy a large home range and are only expected to be near the NICO Project for 5 months of the year during their winter migration. However, due the herd's migratory nature, the caribou may be exposed to similar COPCs at other sites in northern Canada, including the former Rayrock and Colomac mines. Nevertheless, with the conservative assumptions made in the exposure assessment and the use of a NOAEL-based TRV in the toxicity assessment, the ERs calculated for the caribou are orders of magnitude less than the benchmark of 1. Therefore, the risk of adverse health effects to caribou from the NICO Project and other developments in the region (current and foreseeable; i.e., the Cumulative Effects Case) are also considered to be negligible.

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7.0 ACRONYMS AND ABBREVIATIONS

BD	Bulk Density
BW	Body Weight
CCME	Canadian Council for Ministers of the Environment
CDF	Co-Disposal Facility
COPC	Chemicals of Potential Concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
C_{plant}	COPC concentration in plant
C_{prey}	COPC concentration in prey
C_{soil}	COPC concentration in soil
C_{water}	COPC concentration in water
DAR	Developer’s Assessment Report
e.g.	For example (from Latin exempli gratia)
Eco-SSLs	US EPA Ecological Soil Screening Levels
EDI	Estimated daily intake
EDI_{plant}	Exposure due to ingestion of plant
EDI_{prey}	Exposure due to ingestion of prey
EDI_{soil}	Exposure due to ingestion of soil
EDI_{water}	Exposure due to ingestion of water
$\sum EDI$	Sum of the EDIs for all ingestion pathways assessed

ER	Exposure Ratio
ETF	Effluent Treatment Facility
et al.	And others (from Latin et alia)
Fortune	Fortune Minerals Limited
Golder	Golder Associated Ltd.
GNWT	Government of the Northwest Territories
i.e.	That is (from Latin id est)
IR	Ingestion Rate
KLOI	Key Lines of Inquiry
LOAEL	Lowest Observed Adverse Effect Level
LSA	Local study area
MOE	Ministry of Environment
MPOI	Maximum Point of Impingement
n/a	not applicable
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
NPAR	NICO Project Access Road
NSMA	North Slave Métis Alliance
NV	no value
NWT	Northwest Territories
MOE	Ontario Ministry of Environment
PAH	Polycyclic Aromatic Hydrocarbons
the Plant	Mineral Process Plant
RA	Risk Assessment
RSA	Regional Study Area
SARA	Federal Species at Risk Act
SAR	Species at Risk
SCP	Seepage Collection Pond
SON	Subject of Note
spp.	Multiple species
SQG_{HH}	CCME Soil Quality Guideline for the Protection of Human Health – Residential/Parkland
STP	Sewage Treatment Plant
TOR	Terms of Reference
TRV	Toxicity Reference Value
US EPA	United States Environmental Protection Agency
VC	Valued Components

VOC	Volatile Organic Compound
WHRA	Wildlife Health Risk Assessment

7.1 Units

%	percent
<	less than
>	more than
cm^3	cubic centimetre
dw	dry weight
g/cm^3	gram per cubic centimetre
kg	kilogram
kg/day	kilogram per day
km	kilometre
km^2	square kilometre
L	litre
L/day	litre per day
m^2	square metre
masl	meter above sea level
mg	milligram
mg/kg	milligram per kilogram
mg/kg BW/day	milligram per kilogram body weight per day
mg/L	milligram per litre
ww	wet weight

8.0 GLOSSARY

Adverse effect — Means one or more of,

(a) impairment of the quality of the natural environment for any use that can be made of it,

(b) injury or damage to property or to plant or animal life,

(c) harm or material discomfort to any person,

(d) an adverse effect on the health of any person,

(e) impairment of the safety of any person,

(f) rendering any property or plant or animal life unfit for human use, and

(g) loss of enjoyment of normal use of the property.

Background level	The ambient concentration of a chemical in the soil, groundwater, air or sediment in the local environment which is representative or typical of the conditions in urban or rural setting.
Baseline	A surveyed or estimated condition that serves as a reference point to which results of later surveys or predictions are compared.
Baseline Case	The EIA assessment case that includes existing environmental conditions as well as existing and approved projects or activities.
Bioaccumulation Factor (BAF)	This is a measure of accumulation of a chemical in animal tissue, and is defined as the ratio of chemical concentration in the animal tissue to the chemical concentration in the environmental medium (e.g. soil).
Bioavailability	The fraction of an administered dose, typically oral or inhaled, that can cross a biological boundary and enter the systematic or circulatory system (expressed as a unitless value).
Bog	Sphagnum or forest peat materials formed in an ombrotrophic environment due to the slightly elevated nature of the bog, which tends to disassociate it from the nutrient-rich groundwater or surrounding mineral soils. Characterized by a level, raised or sloping peat surface with hollows and hummocks. Mineral-poor, acidic and peat-forming wetlands that receives water only from precipitation.
Boreal Forest	The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.
Carnivore	Animals that feed chiefly on flesh or other animal matter rather than plants.
Complete exposure pathway	An exposure pathway that does not have any natural or man-made barriers that prevents a receptor from being exposed to a contaminant.
Concentration	The quantifiable amount of a chemical in environmental media.
Conceptual Site Model	A diagram that illustrates the exposure pathways between contaminant sources and human receptors, distinguishing those that are relevant or “complete” from those that are incomplete.
Conifer	Trees in the division Pinophyta of the plant kingdom. These are cone-bearing trees with no true flower (e.g., white spruce, black spruce, balsam fir, jack pine and tamarack).
Contaminant	Any solid, liquid, gas, odour, heat, sound, vibration, radiation or combination of any of them resulting directly or indirectly from human activities that may

	cause an adverse effect.
Contaminant of potential concern (COPC)	A chemical that is emitted or released into the environment and poses a potential risk of exposure to humans.
Contamination	A chemical which is present in soil, groundwater or surface water (or other material) at a concentration greater than background, or which is not naturally occurring in the soil, groundwater or surface water (or other material).
Deciduous	Tree species that lose their leaves at the end of the growing season.
Dermal Contact	A person can be exposed to contaminants in soil and water when these media adhere to the skin. That is, contaminants in soil and water may be absorbed through the skin and enter the bloodstream. This is typically a minor exposure pathway that is included in a multi-media risk assessment.
Dose	The actual quantity of a chemical administered to a receptor or to which it is exposed.
Wildlife receptor	Mammals and birds identified as potentially experiencing adverse impacts from exposure to a contaminant, either directly through contact or indirectly through food chain transfer.
Wildlife Health Risk Assessment (WHRA)	It is a process which attempts to estimate and, where possible, quantify risk posed to wildlife by a given condition; this condition is normally the presence of a chemical at concentrations higher than those of uncontaminated background levels.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location. A community of organisms and its environment functioning as an ecological unit. For the purposes of assessment, the ecosystem must be defined according to a particular unit and scale.
Endpoint	Means an effect on a human receptor that can be measured or modeled and described in some quantitative fashion.
Estimated daily intake (EDI)	An estimate of the amount of a contaminant that is ingested daily (in mg/kg bw-d).
Exposure	The contact between a contaminant and an individual or population. The exposure may occur through pathways such as ingestion, dermal absorption or inhalation.

Exposure assessment	The qualitative or quantitative determination or estimation of the magnitude, frequency, duration and routes of exposure for the contaminant, including assessment of the uncertainties associated with the determination.
Exposure pathway	The route by which a receptor comes in to contact with a contaminant.
Exposure Ratio (ER)	A comparison between total exposure from all predicted routes of exposure and the toxicity reference values for chemicals of potential concern. This comparison is calculated by dividing the predicted exposure by the toxicity reference value.
Fen	Sedge peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic environment due to the close association of the material with mineral rich waters. Minerotropic peat-forming wetlands that receive surface moisture from precipitation and groundwater. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium.
Habitat	The place or environment where a plant or animal naturally or normally lives or occurs.
Herbivore	An animal that feeds on plants.
Home range	The geographic extent (area or linear distance) over which an animal travels to satisfy its normal daily requirements for food, water and shelter.
Insectivore	An animal that feeds on insects.
Invertebrates	Any animal lacking a backbone, including all species not classified as vertebrates.
Lowest observed adverse effect level (LOAEL)	The lowest exposure levels at which there are biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control group. LOAELs are typically reported for laboratory test species and uncertainty factors are applied to extrapolate effects to humans.
Mammals	A warm-blooded vertebrate animal of the class Mammalia, whose young feed on milk that is produced by the mother's mammary glands. Unlike other vertebrates, mammals have a diaphragm that separates the heart and lungs from the other internal organs, red blood cells that lack a nucleus, and usually hair or fur. All mammals but the monotremes bear live young. Mammals include rodents, cats, dogs, ungulates, cetaceans, and apes.

Muskeg	A soil type comprised primarily of organic matter. Also known as bog peat
No Observed Adverse Effect Level (NOAEL)	The highest exposure level at which there are no biologically significant increases in the frequency or severity of adverse effect between the exposed population and its appropriate control; some effects may be produced at this level, but they are not considered adverse or precursors of adverse effects. NOAELs are typically reported for laboratory test species and uncertainty factors are applied to extrapolate effects to humans.
Omnivorous	A diet which consists of both plants and animals.
Particulate matter	A mixture of small particles and liquid droplets, often composed of a number of contaminants, dust and soil particles.
Peatland	Areas where there is an accumulation of peat material at least 40 cm thick. These are represented by bog and fen wetlands types.
pH	The degree of acidity (or alkalinity) of soil or solution. The pH scale is generally presented from 1 (most acidic) to 14 (most alkaline). A difference of one pH unit represents a ten-fold change in hydrogen ion concentration.
Piscivore	An animal that feeds on fish.
Polycyclic aromatic hydrocarbons (PAHs)	A large group of organic compounds comprised of two or more aromatic rings. They are by-products of combustion, and are also found in crude oil and a variety of products such as bitumen, asphalt, coal tar pitch volatiles, and unrefined or mildly refined mineral oils. They are emitted into the environment from both natural and anthropogenic sources.
Receptor	The person subjected to chemical exposure.
Regional Study Area (RSA)	Defines the spatial extent related to the cumulative effects resulting from the project and other regional developments.
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.
Risk	The likelihood or probability that harmful effects associated with a contaminant or other stressor will be produced in populations of individuals under their actual conditions of exposure.

Risk assessment (RA)	The scientific examination of the nature and magnitude of risk to define the effects on both human and other receptors of the exposure to contaminant(s). The product of the risk assessment is a statement regarding the probability that populations or individuals so exposed will be harmed and to what degree (risk characterization).
Risk Characterization	The process of evaluating the potential risk to a receptor based on comparison of the estimated exposure to the toxicity reference value.
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from the weathering of rocks, but also includes chemical and biochemical precipitates and decomposed organic material, such as humus.
Soil	The unconsolidated material on the immediate surface of the earth that serves as a natural medium for the growth of plants.
Succession	A series of dynamic changes by which one group of organisms succeeds another through stages leading to a climax community.
Threshold	The dose or exposure below which no harmful effect is expected to occur.
Toxicity	The inherent potential or capacity of a material to cause harmful effects in a living organism. May also be used to describe the observation of an adverse response in an organism due to contaminant exposure.
Toxicity Assessment	The process of determining the amount (concentration or dose) of a chemical to which a receptor may be exposed without the development of adverse effects.
Toxicity reference value (TRV)	An acceptable dose or concentration of a chemical that can be tolerated by a receptor (in mg/kg-day) without causing adverse health effects, and is used as a benchmark for comparison with exposure (EDI) during risk characterization.
Trophic	Related to feeding habits or food relationship of different organisms in a food chain. Animals occupying different positions in a food chain are described as occupying a trophic level (e.g., primary producers, tertiary consumers).
Ungulate	Belonging to the former order Ungulata, now divided into the orders Perissodactyla and Artiodactyla, and composed of the hoofed mammals such as horses, cattle, deer, swine and elephants.

Uptake	Means in exposure assessment, the amount of a contaminant crossing the biological boundaries (for example, skin, lung, gastrointestinal tract) of an organism and reaching the systemic circulation. The term is synonymous with absorbed dose.
Volatile organic compounds (VOCs)	Organic chemical compounds that have high enough vapour pressures under normal conditions to significantly vaporize and enter the atmosphere. There is no clear and widely supported definition of a VOC, but it is often used in reference to carbon-containing gases and vapours such as gasoline fumes and solvents.
Water quality	The physical, chemical and biological characteristics of water. The term is most frequently used in reference to a set of numeric guidelines or standards against which achievement or compliance can be assessed. The most common standards used to assess water quality relate to drinking water, safety of human contact, and for health of ecosystems.
Waterbody	A general term that refers to ponds, bays, lakes, estuaries and marine areas.
Wetlands	Wetlands are land where the water table is at, near or above the surface or which is saturated for a long enough period to promote such features as wet-altered soils and water tolerant vegetation. Wetlands include organic wetlands or "peatlands," and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.
Wildlife	Under the Species at Risk Act, wildlife is defined as a species, subspecies, variety or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus that is wild by nature and is native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Worst-case	A semi-quantitative term referring to the maximum possible exposure, dose or risk that can conceivably occur, whether or not this exposure, dose, or risk actually occurs or is observed in a specific population. It should refer to a hypothetical situation in which everything that can plausibly happen to maximize exposure, dose, or risk does happen. The worst-case may occur in a given population, but since it is usually a very unlikely set of circumstances in most cases, a worst-case estimate will be somewhat higher than what occurs in a specific population.

APPENDIX A

Pathway Analysis for the Wildlife Health Risk Assesment

Table A-1: Pathway Analysis for the Wildlife Health Risk Assesment

Project Component/Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
Construction & Operations: Mine infrastructure footprint (e.g., open pit, site roads, tailings and co-disposal facility, and airstrip)	No effects pathways based on mine footprint that would expose wildlife to chemicals			No linkage
Construction & Operations: NICO Project Access Road	Dust generated from road traffic may deposit to soil, vegetation and surface water. Wildlife can be exposed to metals by direct pathways, such as inhalation, and indirect pathways via uptake through the food chain.	Wildlife	Access road will be as narrow as possible, while maintaining safe construction and operation practices. Watering of roads will suppress dust production. Enforcing speed limits will assist in reducing dust.	Primary
Operations: Operation of Co-Disposal Facility	Exposed tailings may be an attractant to the site for ungulates. Also, dust generated from the co-disposal facility may deposit to soil, vegetation and surface water. Wildlife can be exposed to metals by direct pathways, such as inhalation, and indirect pathways via uptake through the food chain.	All receptors	No current mitigation proposed	Primary
	Water generated from tailings/waste rock management areas will be collected in seepage ponds. Wildlife may have direct access to substances in seepage ponds	All Wildlife	Any potential acid-generating waste rock will be sequestered within the interior of the co-disposal area in a location that will freeze and remain frozen. Overburden directed to the co-disposal area will be used to cover any areas in the core of the pile where potentially acid-generating waste rock is to be sequestered to reduce any infiltration.	Secondary
	Seepage may impact surface water quality around downstream water bodies	Wildlife	Runoff from the tailings and co-disposal area will be captured and diverted to the effluent treatment facility. Any potential acid-generating waste rock will be sequestered within the interior of the co-disposal area in a location that will freeze and remain frozen.	Secondary

Table A-1: Pathway Analysis for the Wildlife Health Risk Assesment (continued)

Project Component/Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
			Overburden directed to the co-disposal area will be used to cover any areas in the core of the pile where potentially acid-generating waste rock is to be sequestered to reduce any infiltration.	
Construction & Operations: Process water and potable water supply during operation of mine	No effect pathways that would expose wildlife to chemicals			No linkage
Construction & Operations: General construction and operation of mine and supporting infrastructure *Site water management*	Discharge of water (e.g. runoff, process water) to surface water could affect surface water quality	Wildlife	The site Water Management Plan will ensure that discharged water is contained on-site. Runoff from the mine site will be captured and diverted to the effluent treatment facility. The site will have sufficient storage capacity to store both operating flows and storm events. Sewage will be treated and the effluent discharged to the tailings basin. Capture and reuse site water to reduce fresh water requirements. Water from tailings thickener and from the tailings basin will be recycled for grinding operations. Excess water from the collection pond (tailings basin) will be recycled in mill operations.	Secondary

Table A-1: Pathway Analysis for the Wildlife Health Risk Assesment (continued)

Project Component/Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
Construction & Operations: General construction and operation of mine and supporting infrastructure *Air emissions and dust deposition*	Air emissions, including dust, generated from on-site activities including, but not limited to, blasting, rock crushing, traffic, operation of equipment and trucks, are a source of direct and indirect exposure. Wildlife can be exposed to metals by direct pathways, such as inhalation, and indirect pathways via uptake through the food chain.	Wildlife	Watering of roads will suppress dust production. Enforcing speed limits will assist in reducing dust. Regular maintenance of equipment to limit emissions. Processing equipment will use high efficiency scrubbers to limit emissions of particulate matter. Dust control systems on rock crushing and other dust generating equipment will limit dust emissions. Operating procedures will be developed that reduce dust generation.	Primary
Construction & Operations: General construction and operation of mine and supporting infrastructure *Noise and general disturbance*	No effects pathways that would expose wildlife to chemicals			No linkage
Construction & Operations: General construction and operation of mine and supporting infrastructure *Collisions*	Collision with vehicles or aircraft causing injury or mortality will not result in chemical exposure to wildlife			No linkage

Table A-1: Pathway Analysis for the Wildlife Health Risk Assesment (continued)

Project Component/Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
<u>Construction & Operations:</u> General construction and operation of mine and supporting infrastructure *Spills*	Potential direct access to spills could affect wildlife. However, given that spills cannot be predicted, it is not possible to assess spills within the wildlife health risk assessment.	Wildlife	A Spill Response Plan will be developed. This Plan and any design features will include measures to block or minimize exposure to potential receptors through the use of fencing, booming, or other means to protect potential receptors Emergency spill kits will be available wherever toxic materials or fuel are stored and transferred. Construction and mining equipment, machinery, and vehicles will be regularly maintained. Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers (i.e., Materials and Waste Management Plan). Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. Reagents and double-walled larger fuel Enviro-Tanks will be located in a bermed, lined storage area. Separate areas will be established for the handling and temporary storage of hazardous wastes. Domestic and recyclable waste dangerous goods will be stored on site in appropriate containers to prevent exposure until they are shipped off site to an approved facility. Individuals working on site and handling hazardous materials will be trained in the Transportation of Dangerous Goods. Soils from petroleum spill areas will be deposited and spread in a lined landfarm cell for bioremediation.	No Linkage

Table A-1: Pathway Analysis for the Wildlife Health Risk Assesment (continued)

Project Component/Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
Closure and Reclamation: Co-Disposal Facility	Long-term seepage from the co-disposal facility can change surface water quality	Wildlife	Develop a closure and reclamation plan (including water quality management post-closure such that water left on-site meets site-specific quality criteria protective of human, wildlife, and aquatic health). Co-disposal facility will be capped during closure to isolate tailings and prevent direct exposure	Primary
	Re-vegetation of the cap on the tailings or waste rock in tailings management area can affect vegetation quality	Wildlife	Salvage and store topsoil, where approrpiate for re-vegetation Use a growth media where topsoil is not available. Develop a closure and reclamation plan. Co-disposal area will be capped during Closure to isolate tailings and prevent leaching. Design of the cap must ensure that water movement through the root film will be minimized and that vegetation will be selected to minimize water movement.	Secondary
Closure and Reclamation: Flooded Open Pit	Final water level in the pit lake and subsequent runoff may affect surface water quality	Wildlife	Establish an active (water treatment plant) or passive treatment system (wetlands) to treat pit discharge waters before discharging to surface waters.	ary
	Water quality in pit lake and outflow may be a source of exposure for wildlife		Flooded mine pit will be a sterile water body because of its physical dimensions with minimal primary production and habitat features capable of supporting aquatic life. As part of the closure plan, the flooded mine pit is not intended to be a functioning part of the ecosystem.	Primary
Closure and Reclamation: Water treatment plant	Decommissioning of the water treatment plant may result in increased chemical concentrations in surface water	Wildlife	The decommissioning of the effluent treatment plant will occur once the effluent discharge in to the wetlands (Seepage Collection Ponds) s below acceptable concentrations. The effluent treatment plant will be re-started and water will be treated, if necessary.	Secondary

APPENDIX B

Soil, Water, and Sediment Screening Tables

Table B-1: Mean Baseline and Incremental Soil Concentrations

Chemicals	Units	Mean Baseline	Maximum Point of Impingement - LSA	Fenceline - LSA	Gameti - RSA	Whati - RSA	Hislop Lake - RSA	Marian River - LSA	Bea Lake	Camp
Metals										
Aluminum	mg/kg	2.18E+04	5.02E+03	5.02E+03	1.13E-01	1.02E-01	2.34E+01	4.26E+01	2.16E+01	2.56E+03
Antimony	mg/kg	9.28E-01	1.04E+00	1.04E+00	2.52E-05	3.52E-05	5.46E-03	9.33E-03	4.89E-03	5.50E-01
Arsenic	mg/kg	1.52E+02	1.29E+02	1.29E+02	2.39E-03	3.11E-03	8.63E-01	1.26E+00	6.56E-01	7.29E+01
Barium	mg/kg	2.89E+02	5.45E+01	5.45E+01	8.13E-04	1.02E-03	2.48E-01	4.57E-01	2.31E-01	2.76E+01
Beryllium	mg/kg	9.40E-01	1.73E-01	1.73E-01	2.69E-06	3.39E-06	8.41E-04	1.49E-03	7.59E-04	8.93E-02
Bismuth	mg/kg	3.41E+00	5.66E+01	5.66E+01	8.98E-04	1.14E-03	2.84E-01	4.95E-01	2.53E-01	2.95E+01
Boron	mg/kg	2.36E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	mg/kg	2.51E-01	5.89E-02	5.89E-02	2.77E-02	4.72E-03	1.61E-03	1.89E-03	2.32E-03	3.91E-02
Calcium	mg/kg	4.99E+03	1.67E+03	1.67E+03	2.79E-02	3.56E-02	9.10E+00	1.51E+01	7.79E+00	8.95E+02
Chlorine	mg/kg	3.04E+02	—	—	—	—	—	—	—	—
Chromium	mg/kg	1.78E+01	5.05E+00	5.05E+00	4.70E-03	8.93E-04	2.38E-02	4.30E-02	2.21E-02	2.58E+00
chromium 6	mg/kg	-	4.59E-06	4.59E-06	1.06E-08	1.67E-08	1.16E-07	1.73E-07	2.39E-07	7.14E-07
Cobalt	mg/kg	3.73E+01	1.61E+01	1.61E+01	4.91E-03	1.17E-03	1.06E-01	1.57E-01	8.17E-02	9.08E+00
Copper	mg/kg	1.45E+02	1.34E+01	1.34E+01	4.85E-03	1.09E-03	6.52E-02	1.16E-01	5.96E-02	6.93E+00
gallium	mg/kg	-	7.06E-03	7.06E-03	4.62E-03	7.83E-04	2.36E-04	2.64E-04	3.33E-04	5.20E-03
indium	mg/kg	-	4.23E-02	4.23E-02	2.77E-02	4.70E-03	1.42E-03	1.58E-03	2.00E-03	3.12E-02
Iron	mg/kg	6.78E+03	1.03E+04	1.03E+04	1.85E-01	2.09E-01	5.11E+01	8.97E+01	4.58E+01	5.37E+03
Lead	mg/kg	6.75E+00	6.17E-01	6.17E-01	4.75E-03	1.04E-03	3.69E-03	6.22E-03	3.91E-03	3.21E-01
Lithium	mg/kg	5.09E+00	1.54E+00	1.54E+00	2.30E-05	2.88E-05	7.03E-03	1.29E-02	6.54E-03	7.80E-01
magnesium	mg/kg	-	2.38E+03	2.38E+03	3.63E-02	4.56E-02	1.12E+01	2.03E+01	1.03E+01	1.22E+03
Manganese	mg/kg	7.03E+02	5.42E+01	5.42E+01	5.52E-03	1.94E-03	2.94E-01	4.90E-01	2.53E-01	2.90E+01
Mercury	mg/kg	1.64E-01	1.16E-03	1.16E-03	4.84E-06	8.50E-06	3.62E-05	5.11E-05	6.72E-05	1.91E-04
Molybdenum	mg/kg	2.40E+00	4.68E-01	4.68E-01	7.66E-06	9.76E-06	2.45E-03	4.17E-03	2.14E-03	2.48E-01
Nickel	mg/kg	9.76E+00	1.35E+00	1.35E+00	2.96E-05	4.16E-05	6.93E-03	1.19E-02	6.19E-03	7.09E-01
palladium	mg/kg	-	7.06E-03	7.06E-03	4.62E-03	7.83E-04	2.36E-04	2.64E-04	3.33E-04	5.20E-03
phosphorus	mg/kg	-	2.10E+01	2.10E+01	4.92E-03	1.17E-03	9.25E-02	1.74E-01	8.79E-02	1.05E+01
potassium	mg/kg	-	5.12E+03	5.12E+03	7.67E-02	9.62E-02	2.35E+01	4.31E+01	2.18E+01	2.60E+03
Selenium	mg/kg	9.01E-01	4.50E-01	4.50E-01	7.21E-06	9.20E-06	2.12E-03	3.83E-03	1.95E-03	2.30E-01
silicon	mg/kg	-	4.45E-01	4.45E-01	2.91E-01	4.93E-02	1.49E-02	1.66E-02	2.10E-02	3.27E-01
Silver	mg/kg	2.14E-01	2.52E-02	2.52E-02	4.62E-03	7.84E-04	3.17E-04	4.22E-04	4.21E-04	1.46E-02
sodium	mg/kg	-	5.19E+02	5.19E+02	8.04E-03	1.01E-02	2.51E+00	4.46E+00	2.27E+00	2.68E+02

Table B-1: Mean Baseline and Incremental Soil Concentrations

Chemicals	Units	Mean Baseline	Maximum Point of Impingement - LSA	Fenceline - LSA	Gameti - RSA	Whati - RSA	Hislop Lake - RSA	Marian River - LSA	Bea Lake	Camp
Strontium	mg/kg	7.63E+01	2.10E+00	2.10E+00	3.16E-05	3.97E-05	9.71E-03	1.77E-02	8.99E-03	1.07E+00
Thallium	mg/kg	2.35E-01	5.54E-02	5.54E-02	8.42E-07	1.06E-06	2.59E-04	4.70E-04	2.39E-04	2.83E-02
Thorium	mg/kg	1.42E+00	—	—	—	—	—	—	—	—
Tin	mg/kg	5.51E-01	5.49E-01	5.49E-01	8.63E-06	1.09E-05	2.72E-03	4.77E-03	2.43E-03	2.85E-01
Titianium	mg/kg	5.70E+02	1.65E+02	1.65E+02	2.56E-03	3.22E-03	7.96E-01	1.42E+00	7.23E-01	8.52E+01
Uranium	mg/kg	1.93E+01	6.04E-01	6.04E-01	9.67E-06	1.23E-05	3.08E-03	5.31E-03	2.72E-03	3.17E-01
Vanadium	mg/kg	2.55E+01	3.65E+00	3.65E+00	5.71E-05	7.23E-05	1.73E-02	3.11E-02	1.58E-02	1.87E+00
yttrium	mg/kg	-	1.35E+00	1.35E+00	2.11E-05	2.66E-05	6.61E-03	1.17E-02	5.94E-03	6.98E-01
Zinc		5.12E+01	2.91E+00	2.91E+00	3.24E-02	5.56E-03	1.46E-02	2.60E-02	1.49E-02	1.50E+00
PAHs										
Total Dioxin/Furans	mg/kg	-	1.23E-09	1.23E-09	3.48E-12	5.74E-12	3.30E-11	4.83E-11	6.59E-11	1.94E-10
2-Methylnaphthalene	mg/kg	-	8.50E-02	8.50E-02	4.81E-05	7.78E-05	1.57E-03	1.94E-03	1.33E-03	2.34E-02
Acenaphthene	mg/kg	1.00E-03	8.77E-05	8.77E-05	6.69E-05	1.13E-05	3.18E-06	3.55E-06	4.65E-06	7.08E-05
Acenaphthylene	mg/kg	1.00E-03	1.17E-02	1.17E-02	6.87E-03	1.17E-03	3.77E-04	4.24E-04	5.21E-04	8.03E-03
Anthracene	mg/kg	1.00E-03	2.36E-04	2.36E-04	7.93E-05	1.36E-05	6.21E-06	7.03E-06	7.59E-06	1.20E-04
Benzo(a)anthracene	mg/kg	7.09E-03	8.26E-05	8.26E-05	5.96E-05	1.01E-05	2.92E-06	3.26E-06	4.21E-06	6.43E-05
Benzo(a)pyrene	mg/kg	1.91E-01	6.13E-05	6.13E-05	9.52E-06	1.65E-06	1.36E-06	1.58E-06	1.43E-06	2.36E-05
Benzo(b,j,k)fluoranthene	mg/kg	1.23E-02	1.13E-03	1.13E-03	3.32E-04	5.68E-05	2.87E-05	3.26E-05	3.40E-05	5.44E-04
Benzo(ghi)perylene	mg/kg	1.24E-02	1.00E-03	1.00E-03	2.07E-04	3.58E-05	2.33E-05	2.70E-05	2.58E-05	4.21E-04
Chrysene	mg/kg	4.89E-03	2.40E-04	2.40E-04	2.16E-04	3.65E-05	9.38E-06	1.04E-05	1.43E-05	2.15E-04
Dibenzo(ah)anthracene	mg/kg	3.68E-03	8.46E-05	8.46E-05	2.27E-05	3.89E-06	2.09E-06	2.39E-06	2.44E-06	3.91E-05
Fluoranthene	mg/kg	5.59E-02	5.89E-04	5.89E-04	2.51E-04	4.27E-05	1.67E-05	1.89E-05	2.15E-05	3.37E-04
Fluorene	mg/kg	3.64E-03	1.92E-04	1.92E-04	1.08E-04	1.83E-05	6.04E-06	6.79E-06	8.27E-06	1.28E-04
Indeno(1,2,3-cd)pyrene	mg/kg	9.99E-03	4.98E-05	4.98E-05	2.10E-05	3.57E-06	1.41E-06	1.59E-06	1.81E-06	2.84E-05
Naphthalene	mg/kg	3.75E-03	1.89E-03	1.89E-03	8.75E-04	1.49E-04	5.53E-05	6.23E-05	7.25E-05	1.13E-03
Phenanthrene	mg/kg	5.31E-02	1.62E-03	1.62E-03	1.15E-03	1.95E-04	5.68E-05	6.35E-05	8.17E-05	1.25E-03
Pyrene	mg/kg	1.00E-03	2.99E-03	2.99E-03	9.47E-04	1.62E-04	7.73E-05	8.76E-05	9.33E-05	1.49E-03

- = No value; LSA = Local Study Area; RSA = Regional Study Area; mg/kg = milligram per kilogram

Table B-2: Comparison of Predicted Soil Concentrations to Guidelines and Baseline Concentrations

Chemical	CCME Soil Quality Guidelines (mg/kg)[a]	U.S. EPA Ecological Soil Screening Levels (mg/kg)		Baseline + 10%[h] (mg/kg)	Maximum Point of Impingement - LSA[i] (mg/kg)	Fenceline - LSA[i] (mg/kg)	Gameti - RSA[i] (mg/kg)	Whati - RSA[i] (mg/kg)	Hislop Lake - RSA[i] (mg/kg)	Marian River - LSA[i] (mg/kg)	Bea Lake[i] (mg/kg)	Camp[i] (mg/kg)	Chemical of Concern?
Total Metals		***Mammalian*** [d]	***Avian*** [e]										
Aluminum (Al)	NV	NV	NV	2.40E+04	2.7E+04	2.7E+04	2.2E+04	2.2E+04	2.2E+04	2.2E+04	2.2E+04	2.4E+04	No
Antimony (Sb)	NV	0.27	NV	1.02E+00	**2.0E+00**	**2.0E+00**	**9.3E-01**	**9.3E-01**	**9.3E-01**	**9.4E-01**	**9.3E-01**	**1.5E+00**	**Yes**
Arsenic (As)	17.00	46	43	1.67E+02	**2.8E+02**	**2.8E+02**	**1.5E+02**	**1.5E+02**	**1.5E+02**	**1.5E+02**	**1.5E+02**	**2.3E+02**	**Yes**
Barium (Ba)	NV	2000	NV	3.18E+02	3.4E+02	3.4E+02	2.9E+02	2.9E+02	2.9E+02	2.9E+02	2.9E+02	3.2E+02	No
Beryllium (Be)	4[c]	21	NV	1.03E+00	1.1E+00	1.1E+00	9.4E-01	9.4E-01	9.4E-01	9.4E-01	9.4E-01	1.0E+00	No
Bismuth (Bi)	NV	NV	NV	3.75E+00	6.0E+01	6.0E+01	3.4E+00	3.4E+00	3.7E+00	3.9E+00	3.7E+00	3.3E+01	No
Boron (B)	NV	NV	NV	2.59E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01	No
Cadmium (Cd)	10	0.36	0.77	2.76E-01	3.1E-01	3.1E-01	2.8E-01	2.6E-01	2.5E-01	2.5E-01	2.5E-01	2.9E-01	No
Calcium (Ca)	NV	NV	NV	5.49E+03	6.7E+03	6.7E+03	5.0E+03	5.0E+03	5.0E+03	5.0E+03	5.0E+03	5.9E+03	No
Chlorine	NV	NV	NV	3.34E+02	—	—	—	—	—	—	—	—	No
Chromium (Cr)	64[b]	34	26	1.96E+01	2.3E+01	2.3E+01	1.8E+01	1.8E+01	1.8E+01	1.8E+01	1.8E+01	2.0E+01	No
Chromium 6	NV	130	NV	NV	4.6E-06	4.6E-06	1.1E-08	1.7E-08	1.2E-07	1.7E-07	2.4E-07	7.1E-07	No
Cobalt (Co)	50[c]	230	120	4.11E+01	5.3E+01	5.3E+01	3.7E+01	3.7E+01	3.7E+01	3.7E+01	3.7E+01	4.6E+01	No
Copper (Cu)	63	49	28	1.60E+02	**1.6E+02**	**1.6E+02**	**1.5E+02**	**1.5E+02**	**1.5E+02**	**1.5E+02**	**1.5E+02**	**1.5E+02**	No
Gallium (Ga)	NV	NV	NV	NV	7.1E-03	7.1E-03	4.6E-03	7.8E-04	2.4E-04	2.6E-04	3.3E-04	5.2E-03	No
Indium (In)	NV	NV	NV	NV	4.2E-02	4.2E-02	2.8E-02	4.7E-03	1.4E-03	1.6E-03	2.0E-03	3.1E-02	No
Iron (Fe)	NV	NV	NV	7.45E+03	1.7E+04	1.7E+04	6.8E+03	6.8E+03	6.8E+03	6.9E+03	6.8E+03	1.2E+04	No
Lead (Pb)	300	56	11	7.42E+00	7.4E+00	7.4E+00	6.8E+00	6.7E+00	6.7E+00	6.8E+00	6.7E+00	7.1E+00	No
Lithium (Li)	NV	NV	NV	5.60E+00	6.6E+00	6.6E+00	5.1E+00	5.1E+00	5.1E+00	5.1E+00	5.1E+00	5.9E+00	No
Magnesium (Mg)	NV	NV	NV	NV	2.4E+03	2.4E+03	3.6E-02	4.6E-02	1.1E+01	2.0E+01	1.0E+01	1.2E+03	No
Manganese (Mn)	NV	4000	4300	7.73E+02	7.6E+02	7.6E+02	7.0E+02	7.0E+02	7.0E+02	7.0E+02	7.0E+02	7.3E+02	No
Mercury (Hg)	12	NV	NV	1.81E-01	1.7E-01	1.7E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01	No
Molybdenum (Mo)	10[c]	NV	NV	2.64E+00	2.9E+00	2.9E+00	2.4E+00	2.4E+00	2.4E+00	2.4E+00	2.4E+00	2.6E+00	No
Nickel (Ni)	50	130	210	1.07E+01	1.1E+01	1.1E+01	9.8E+00	9.8E+00	9.8E+00	9.8E+00	9.8E+00	1.0E+01	No
Palladium (Pd)	NV	NV	NV	NV	7.1E-03	7.1E-03	4.6E-03	7.8E-04	2.4E-04	2.6E-04	3.3E-04	5.2E-03	No
Phosphorus (P)	NV	NV	NV	NV	2.1E+01	2.1E+01	4.9E-03	1.2E-03	9.2E-02	1.7E-01	8.8E-02	1.1E+01	No
Potassium (K)	NV	NV	NV	NV	5.1E+03	5.1E+03	7.7E-02	9.6E-02	2.3E+01	4.3E+01	2.2E+01	2.6E+03	No
Selenium (Se)	1	0.63	1.2	9.92E-01	**1.4E+00**	**1.4E+00**	**9.0E-01**	**9.0E-01**	**9.0E-01**	**9.1E-01**	**9.0E-01**	**1.1E+00**	**Yes**
Silicon (Si)	NV	NV	NV	NV	4.4E-01	4.4E-01	2.9E-01	4.9E-02	1.5E-02	1.7E-02	2.1E-02	3.3E-01	No
Silver (Ag)	20[c]	14	4.2	2.35E-01	2.4E-01	2.4E-01	2.2E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.3E-01	No
Sodium (Na)	NV	NV	NV	NV	5.2E+02	5.2E+02	8.0E-03	1.0E-02	2.5E+00	4.5E+00	2.3E+00	2.7E+02	No
Strontium (Sr)	NV	NV	NV	8.39E+01	7.8E+01	7.8E+01	7.6E+01	7.6E+01	7.6E+01	7.6E+01	7.6E+01	7.7E+01	No
Thallium (Tl)	1.4	NV	NV	2.59E-01	2.9E-01	2.9E-01	2.4E-01	2.4E-01	2.4E-01	2.4E-01	2.4E-01	2.6E-01	No
Thorium	NV	NV	NV	1.56E+00	—	—	—	—	—	—	—	—	No
Tin (Sn)	50[c]	NV	NV	6.06E-01	1.1E+00	1.1E+00	5.5E-01	5.5E-01	5.5E-01	5.6E-01	5.5E-01	8.4E-01	No
Titanium (Ti)	NV	NV	NV	6.27E+02	7.4E+02	7.4E+02	5.7E+02	5.7E+02	5.7E+02	5.7E+02	5.7E+02	6.6E+02	No
Uranium (U)	500	NV	NV	2.12E+01	2.0E+01	2.0E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	2.0E+01	No
Vanadium (V)	130[c]	280	7.8	2.81E+01	**2.9E+01**	**2.9E+01**	**2.6E+01**	**2.6E+01**	**2.6E+01**	**2.6E+01**	**2.6E+01**	**2.7E+01**	**Yes**
Yttrium (Y)	NV	NV	NV	NV	1.3E+00	1.3E+00	2.1E-05	2.7E-05	6.6E-03	1.2E-02	5.9E-03	7.0E-01	No
Zinc (Zn)	200[c]	79	46	5.63E+01	**5.4E+01**	**5.4E+01**	**5.1E+01**	**5.1E+01**	**5.1E+01**	**5.1E+01**	**5.1E+01**	**5.3E+01**	No
Total Dioxins and Furans	NV	NV	NV	NV	1.2E-09	1.2E-09	3.5E-12	5.7E-12	3.3E-11	4.8E-11	6.6E-11	1.9E-10	No
PAH Groups			NV	NV									
2-Methylnaphthalene	NV	NV	NV	NV	8.5E-02	8.5E-02	4.8E-05	7.8E-05	1.6E-03	1.9E-03	1.3E-03	2.3E-02	No
Acenapthene	NV	NV	NV	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03	No
Acenapthylene	NV	NV	NV	1.1E-03	1.3E-02	1.3E-02	7.9E-03	2.2E-03	1.4E-03	1.4E-03	1.5E-03	9.0E-03	No
Anthracene	2.5	NV	NV	1.1E-03	1.2E-03	1.2E-03	1.1E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03	No
Fluorene	NV	NV	NV	3.0E-02	2.8E-02	2.8E-02	2.8E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02	2.8E-02	No
Naphthalene	0.013	NV	NV	1.3E-02	1.3E-02	1.3E-02	1.2E-02	1.2E-02	1.1E-02	1.1E-02	1.1E-02	1.3E-02	No
Phenanthrene	0.046	NV	NV	2.0E-01	1.8E-01	1.8E-01	1.8E-01	1.8E-01	1.8E-01	1.8E-01	1.8E-01	1.8E-01	No
Benzo(a)anthracene	1	NV	NV	6.5E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02	No
Benzo(a)pyrene	20	NV	NV	2.1E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	No
Benzo(b+k)fluoranthene	1	NV	NV	1.3E-01	1.2E-01	1.2E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	No
Benzo(g,h,i)perylene	NV	NV	NV	3.4E-02	3.2E-02	3.2E-02	3.1E-02	3.1E-02	3.1E-02	3.1E-02	3.1E-02	3.1E-02	No
Chrysene	NV	NV	NV	4.4E-02	4.0E-02	4.0E-02	4.0E-02	4.0E-02	4.0E-02	4.0E-02	4.0E-02	4.0E-02	No
Dibenzo(a,h)anthracene	1	NV	NV	2.1E-02	1.9E-02	1.9E-02	1.9E-02	1.9E-02	1.9E-02	1.9E-02	1.9E-02	1.9E-02	No
Fluoranthene	50	NV	NV	3.0E-01	2.8E-01	2.8E-01	2.8E-01	2.8E-01	2.8E-01	2.8E-01	2.8E-01	2.8E-01	No
Indeno(1,2,3-c,d)pyrene	1	NV	NV	4.1E-02	3.7E-02	3.7E-02	3.7E-02	3.7E-02	3.7E-02	3.7E-02	3.7E-02	3.7E-02	No
Pyrene	10	NV	NV	1.1E-03	4.0E-03	4.0E-03	1.9E-03	1.2E-03	1.1E-03	1.1E-03	1.1E-03	2.5E-03	No
Sum Low PAH	NV	100[f]	NV	2.4E-01	3.2E-01	3.2E-01	2.3E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.6E-01	No
Sum High PAH	NV	1.1[g]	NV	2.7E+00	**2.5E+00**	**2.5E+00**	**2.5E+00**	**2.5E+00**	**2.5E+00**	**2.5E+00**	**2.5E+00**	**2.5E+00**	No

[a] CCME (Canadian Council of Ministers of the Environment) Soil Quality Guidelines for the Protection of Environmental Health - Residential/Parkland.
[b] Guideline for total chromium
[c] SQG_{HH} (CCME Soil Quality Guideline for the Protection of Human Health - Residential/Parkland).
[d] U.S. EPA ECO-SSL (Ecological Screening Level) for Mammalian Wildlife.
[e] U.S. EPA ECO-SSL for Avian Wildlife.
[f] Total PAHs Low Molecular Weight.
[g] Total PAHs High Molecular Weight.
[h] Average background concentration used for metals; maximum background concentration used for PAHs.
[i] Incremental soil concentration from particulare deposition + average background concentration used for metals; incremental soil concentration from particulate deposition + maximum background concentration used for PAH
NV = No value; LSA = Local Study Area; RSA = Regional Study Area; mg/kg = miligram per kilogram

1.1E+00	= Exceeds Background + 10% and Standard
9.3E-01	= Exceeds Standard
8.1E+03	= Exceeds Background + 10%

Table B-3: Comparison of Predicted Surface Water Concentrations to Guidelines and Baseline Concentrations

Chemical	Units	CCME Water Quality Guidelines (mg/L)[a]	Sample et al. 1996 (mg/L)[b]	Nico Lake						Peanut Lake					
				Baseline Concentration[c]	Baseline + 10%	Construction 95th P	Operations 95th P	Active Closure 95th P	Post-Closure 95th P	Baseline Concentration[c]	Baseline + 10%	Construction 95th P	Operations 95th P	Active Closure 95th P	Post-Closure 95th P
Total Metals															
Al	mg/L	5	NV	4.3E-02	4.7E-02	3.3E-01	1.3E+00	1.1E+00	2.0E-01	1.0E-01	1.1E-01	5.1E-01	7.3E-01	5.3E-01	1.7E-01
Sb	mg/L	NV	0.29	2.2E-04	2.5E-04	3.5E-04	1.3E-03	2.2E-03	3.7E-03	2.1E-04	2.3E-04	3.6E-04	5.2E-04	7.3E-04	1.2E-03
As	mg/L	0.03	NV	2.1E-02	2.3E-02	2.1E-02	**4.4E-02**	**4.0E-02**	1.9E-02	4.0E-03	4.4E-03	1.7E-02	2.4E-02	1.7E-02	6.3E-03
Ba	mg/L	NV	23.1	8.3E-03	9.1E-03	1.3E-02	2.3E-02	2.4E-02	2.1E-02	1.0E-02	1.1E-02	1.3E-02	1.6E-02	1.5E-02	1.3E-02
Be	mg/L	0.1	NV	5.0E-04	5.5E-04	3.8E-05	1.1E-04	1.3E-04	1.5E-04	5.2E-04	5.7E-04	3.7E-05	6.7E-05	6.7E-05	5.1E-05
B	mg/L	5	NV	1.9E-02	2.0E-02	9.4E-03	1.5E-02	2.0E-02	2.5E-02	2.0E-02	2.2E-02	9.3E-03	1.6E-02	1.8E-02	1.3E-02
Cd	mg/L	0.08	NV	2.0E-04	2.3E-04	2.5E-05	5.8E-05	5.0E-05	4.2E-05	1.6E-04	1.7E-04	2.9E-05	4.0E-05	3.2E-05	2.9E-05
Cr	mg/L	0.05	NV	1.3E-03	1.4E-03	7.2E-04	1.8E-03	1.8E-03	2.0E-03	1.4E-03	1.5E-03	1.0E-03	1.2E-03	1.1E-03	1.0E-03
Co	mg/L	1	NV	8.7E-04	9.6E-04	1.9E-03	6.1E-03	5.5E-03	1.6E-03	6.2E-04	6.8E-04	1.9E-03	3.5E-03	2.6E-03	5.8E-04
Cu	mg/L	0.5	NV	1.7E-03	1.9E-03	2.5E-03	4.9E-03	4.8E-03	4.1E-03	9.5E-04	1.0E-03	2.2E-03	2.9E-03	2.5E-03	1.9E-03
Fe	mg/L	NV	NV	6.9E-01	7.5E-01	9.5E-01	3.3E+00	2.9E+00	8.8E-01	3.2E-01	3.6E-01	1.2E+00	1.8E+00	1.4E+00	5.8E-01
Pb	mg/L	0.1	NV	6.2E-04	6.8E-04	1.4E-04	4.3E-04	7.8E-04	1.8E-03	6.6E-04	7.3E-04	1.5E-04	2.0E-04	2.6E-04	5.8E-04
Mn	mg/L	NV	377	7.4E-02	8.2E-02	3.4E-02	4.8E-02	5.7E-02	7.8E-02	3.9E-02	4.3E-02	4.3E-02	5.6E-02	5.9E-02	6.0E-02
Hg	mg/L	0.003	NV	5.4E-05	6.0E-05	1.1E-05	1.5E-05	1.5E-05	2.6E-05	5.2E-05	5.7E-05	1.3E-05	1.4E-05	1.5E-05	1.6E-05
Mo	mg/L	0.5	NV	1.5E-03	1.7E-03	5.3E-04	1.3E-03	2.8E-03	5.9E-03	1.5E-03	1.6E-03	2.7E-04	1.4E-03	1.5E-03	1.8E-03
Ni	mg/L	1	NV	8.2E-04	9.0E-04	8.0E-04	1.1E-03	1.2E-03	1.6E-03	9.1E-04	1.0E-03	1.2E-03	1.4E-03	1.5E-03	1.4E-03
Se	mg/L	0.05	NV	2.3E-04	2.5E-04	2.3E-04	1.6E-03	2.6E-03	1.8E-03	2.5E-04	2.8E-04	2.4E-04	1.5E-03	1.7E-03	6.4E-04
Ag	mg/L	NV	0.0015	6.1E-04	6.7E-04	1.0E-05	8.3E-05	6.7E-05	1.0E-04	6.6E-04	7.2E-04	1.1E-05	9.1E-05	6.1E-05	3.5E-05
Tl	mg/L	NV	0.032	5.5E-03	6.1E-03	5.1E-06	7.0E-04	5.1E-04	8.7E-04	6.1E-03	6.7E-03	6.3E-06	1.7E-04	1.5E-04	2.5E-04
U	mg/L	0.2	NV	5.7E-03	6.3E-03	3.7E-04	4.0E-03	6.4E-03	9.5E-03	6.2E-03	6.8E-03	2.6E-04	1.9E-03	2.5E-03	2.9E-03
V	mg/L	0.1	NV	4.1E-04	4.5E-04	7.3E-04	1.2E-03	1.2E-03	9.6E-04	4.3E-04	4.8E-04	7.8E-04	9.2E-04	9.3E-04	8.7E-04
Zn	mg/L	50	NV	2.6E-03	2.8E-03	4.9E-03	7.9E-03	1.3E-02	2.8E-02	3.7E-03	4.1E-03	5.6E-03	6.0E-03	6.8E-03	1.1E-02

[a] CCME (Canadian Council of Ministers of the Environment) Water Quality Guidelines for Livestock Water.

[b] The value provided is the lowest of the NOAEL-based benchmarks for water provided in Table 12 of Sample et al. (1996).

[c] Average measured baseline concentration.

95th P = 95th Percentile; NV = No value; mg/L = miligram per litre

1.1E+00	= Exceeds Background + 10% and Standard
9.3E-01	= Exceeds Standard
8.1E+03	= Exceeds Background + 10%

Table B-3: Comparison of Predicted Surface Water Concentrations to Guidelines and Baseline Concentrations

Chemical	Units	CCME Water Quality Guidelines (mg/L)[a]	Sample et al. 1996 (mg/L)[b]	Burke Lake						Marian River					
				Baseline Concentration[c]	Baseline + 10%	Construction 95th P	Operations 95th P	Active Closure 95th P	Post-Closure 95th P	Baseline Concentration[c]	Baseline + 10%	Construction 95th P	Operations 95th P	Active Closure 95th P	Post-Closure 95th P
Total Metals															
Al	mg/L	5	NV	7.1E-02	7.9E-02	2.1E-01	5.8E-01	4.9E-01	1.4E-01	7.3E-02	8.0E-02	7.2E-02	1.1E-01	9.5E-02	7.1E-02
Sb	mg/L	NV	0.29	3.1E-04	3.4E-04	3.0E-04	4.3E-04	4.7E-04	7.3E-04	1.7E-04	1.8E-04	5.0E-05	5.8E-05	6.0E-05	7.3E-05
As	mg/L	0.03	NV	3.5E-03	3.8E-03	6.7E-03	1.8E-02	1.5E-02	3.7E-03	6.0E-04	6.6E-04	1.2E-03	1.7E-03	1.4E-03	1.1E-03
Ba	mg/L	NV	23.1	9.1E-03	1.0E-02	1.1E-02	1.5E-02	1.4E-02	1.2E-02	1.4E-02	1.6E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02
Be	mg/L	0.1	NV	5.4E-04	5.9E-04	1.9E-05	4.1E-05	4.8E-05	3.1E-05	5.2E-04	5.7E-04	3.2E-05	3.2E-05	3.2E-05	3.2E-05
B	mg/L	5	NV	1.9E-02	2.1E-02	8.2E-03	1.0E-02	1.3E-02	9.5E-03	2.3E-02	2.6E-02	3.5E-02	3.5E-02	3.5E-02	3.5E-02
Cd	mg/L	0.08	NV	1.6E-04	1.8E-04	2.0E-05	3.1E-05	2.8E-05	2.2E-05	1.1E-04	1.2E-04	4.7E-05	4.7E-05	4.7E-05	4.7E-05
Cr	mg/L	0.05	NV	1.4E-03	1.5E-03	8.0E-04	1.1E-03	9.9E-04	8.8E-04	1.4E-03	1.6E-03	7.6E-04	7.7E-04	7.7E-04	7.7E-04
Co	mg/L	1	NV	7.2E-04	7.9E-04	9.2E-04	2.5E-03	2.2E-03	4.0E-04	6.2E-04	6.8E-04	2.2E-04	2.8E-04	2.6E-04	2.1E-04
Cu	mg/L	0.5	NV	1.3E-03	1.4E-03	1.7E-03	2.6E-03	2.3E-03	1.6E-03	7.4E-04	8.2E-04	1.7E-03	1.7E-03	1.7E-03	1.7E-03
Fe	mg/L	NV	NV	6.6E-01	7.3E-01	6.3E-01	1.5E+00	1.3E+00	5.2E-01	1.6E-01	1.8E-01	2.8E-01	3.1E-01	3.0E-01	2.8E-01
Pb	mg/L	0.1	NV	7.5E-04	8.3E-04	1.3E-04	1.7E-04	1.9E-04	3.4E-04	4.6E-04	5.1E-04	2.9E-04	2.9E-04	2.9E-04	2.9E-04
Mn	mg/L	NV	377	1.3E-01	1.4E-01	3.6E-02	5.1E-02	5.3E-02	5.2E-02	2.5E-02	2.7E-02	6.3E-02	6.2E-02	6.2E-02	6.2E-02
Hg	mg/L	0.003	NV	6.2E-05	6.8E-05	1.2E-05	1.2E-05	1.3E-05	1.4E-05	3.6E-05	3.9E-05	8.0E-05	7.7E-05	8.0E-05	7.8E-05
Mo	mg/L	0.5	NV	1.5E-03	1.6E-03	2.4E-04	6.4E-04	9.9E-04	1.0E-03	1.5E-03	1.6E-03	4.3E-04	4.3E-04	4.4E-04	4.4E-04
Ni	mg/L	1	NV	8.5E-04	9.3E-04	1.1E-03	1.2E-03	1.2E-03	1.2E-03	9.7E-04	1.1E-03	2.0E-03	2.0E-03	2.0E-03	2.0E-03
Se	mg/L	0.05	NV	2.4E-04	2.6E-04	2.1E-04	6.5E-04	1.1E-03	4.1E-04	2.8E-04	3.1E-04	7.0E-04	7.1E-04	7.2E-04	7.0E-04
Ag	mg/L	NV	0.0015	7.4E-04	8.1E-04	9.0E-06	4.2E-05	4.7E-05	2.1E-05	4.7E-04	5.2E-04	1.2E-05	1.2E-05	1.2E-05	1.2E-05
Tl	mg/L	NV	0.032	6.8E-03	7.5E-03	3.4E-06	9.1E-05	8.2E-05	1.2E-04	4.0E-03	4.4E-03	2.3E-06	5.7E-06	5.6E-06	8.1E-06
U	mg/L	0.2	NV	7.0E-03	7.7E-03	2.8E-04	1.0E-03	1.4E-03	1.6E-03	4.6E-03	5.1E-03	1.7E-03	1.7E-03	1.7E-03	1.8E-03
V	mg/L	0.1	NV	1.9E-03	2.1E-03	6.8E-04	8.7E-04	8.4E-04	8.0E-04	5.8E-04	6.4E-04	1.1E-03	1.1E-03	1.1E-03	1.1E-03
Zn	mg/L	50	NV	4.9E-03	5.3E-03	5.3E-03	5.9E-03	5.9E-03	7.8E-03	6.2E-03	6.8E-03	2.3E-02	2.3E-02	2.3E-02	2.4E-02

[a] CCME (Canadian Council of Ministers of the Environment) Water Quality Guidelines for Livestock Water.

[b] The value provided is the lowest of the NOAEL-based benchmarks for water provided in Table 12 of Sample et al. (1996).

[c] Average measured baseline concentration.

95th P = 95th Percentile; NV = No value; mg/L = miligram per litre

1.1E+00	= Exceeds Background + 10% and Standard
9.3E-01	= Exceeds Standard
8.1E+03	= Exceeds Background + 10%

Table B-3: Comparison of Predicted Surface Water Concentrations to Guidelines and Baseline Concentrations

Chemical	Units	CCME Water Quality Guidelines (mg/L)[a]	Sample et al. 1996 (mg/L)[b]	Simulated Post-Closure Pit Lake Water Quality - Scenario 3b		Simulated Post-Closure Pit Lake Water Quality - Scenario 3b	
				0 to 120 Years	0 to 120 Years	0 to 120 Years	~ Year 120
				Maximum In-Pit Water Quality	Maximum In-Pit Water Quality	Maximum Effluent Water	Maximum Effluent Water Quality
Total Metals							
Al	mg/L	5	NV	2.35E+00	2.46E+00	2.32E+00	1.30
Sb	mg/L	NV	0.29	1.87E-02	1.87E-02	8.00E-03	0.01
As	mg/L	0.03	NV	**6.42E-01**	**6.27E-01**	**3.38E-01**	**0.27**
Ba	mg/L	NV	23.1	1.89E-01	1.89E-01	8.40E-02	0.08
Be	mg/L	0.1	NV	9.36E-04	9.78E-04	7.08E-04	0.00007
B	mg/L	5	NV	-	-	0.00E+00	
Cd	mg/L	0.08	NV	1.29E-04	1.28E-04	8.68E-05	0.0001
Cr	mg/L	0.05	NV	4.43E-03	5.40E-03	4.61E-03	0.001
Co	mg/L	1	NV	**1.44E+00**	**1.44E+00**	3.99E-01	0.40
Cu	mg/L	0.5	NV	7.44E-02	7.68E-02	3.36E-02	0.01
Fe	mg/L	NV	NV	5.95E+00	5.94E+00	5.50E+00	4.15
Pb	mg/L	0.1	NV	6.91E-03	7.15E-03	3.75E-03	0.001
Mn	mg/L	NV	377	1.44E-01	1.44E-01	7.64E-02	0.08
Hg	mg/L	0.003	NV	-	-	0.00E+00	
Mo	mg/L	0.5	NV	3.18E-02	3.12E-02	1.52E-02	0.02
Ni	mg/L	1	NV	4.03E-02	4.05E-02	2.04E-02	0.02
Se	mg/L	0.05	NV	2.47E-02	2.46E-02	7.26E-03	0.01
Ag	mg/L	NV	0.0015	1.26E-04	1.26E-04	1.34E-04	0.0001
Tl	mg/L	NV	0.032	6.77E-04	6.77E-04	7.65E-04	0.001
U	mg/L	0.2	NV	4.47E-03	4.47E-03	3.99E-03	0.004
V	mg/L	0.1	NV	3.65E-03	3.65E-03	3.26E-03	0.003
Zn	mg/L	50	NV	1.65E-01	1.68E-01	5.62E-02	0.06

[a] CCME (Canadian Council of Ministers of the Environment) Water Quality Guidelines for Livestock Water.

[b] The value provided is the lowest of the NOAEL-based benchmarks for water provided in Table 12 of Sample et al. (1996).

[c] Average measured baseline concentration.

95th P = 95th Percentile; NV = No value; mg/L = miligram per litre

1.1E+00	= Exceeds Background + 10% and Standard
9.3E-01	= Exceeds Standard
8.1E+03	= Exceeds Background + 10%

Table B-3: Comparison of Predicted Surface Water Concentrations to Guidelines and Baseline Concentrations

Chemical	Units	CCME Water Quality Guidelines (mg/L)[a]	Sample et al. 1996 (mg/L)[b]	Simulated Post-Closure Pit Lake Water Quality - Scenario 3b	
				> 120 years	> 120 years
				Expected Steady State Effluent Water	Expected Steady State Effluent Water
Total Metals					
Al	mg/L	5	NV	1.30	2.31E+00
Sb	mg/L	NV	0.29	0.01	7.38E-03
As	mg/L	0.03	NV	**0.24**	**3.08E-01**
Ba	mg/L	NV	23.1	0.08	7.91E-02
Be	mg/L	0.1	NV	0.0001	6.41E-04
B	mg/L	5	NV		-
Cd	mg/L	0.08	NV	0.0001	8.68E-05
Cr	mg/L	0.05	NV	0.001	4.61E-03
Co	mg/L	1	NV	0.32	3.22E-01
Cu	mg/L	0.5	NV	0.01	3.15E-02
Fe	mg/L	NV	NV	4.15	5.50E+00
Pb	mg/L	0.1	NV	0.0005	2.80E-03
Mn	mg/L	NV	377	0.07	7.23E-02
Hg	mg/L	0.003	NV		-
Mo	mg/L	0.5	NV	0.01	1.41E-02
Ni	mg/L	1	NV	0.02	1.91E-02
Se	mg/L	0.05	NV	0.01	5.99E-03
Ag	mg/L	NV	0.0015	0.0001	1.34E-04
Tl	mg/L	NV	0.032	0.001	7.65E-04
U	mg/L	0.2	NV	0.004	3.99E-03
V	mg/L	0.1	NV	0.003	3.26E-03
Zn	mg/L	50	NV	0.05	4.91E-02

[a] CCME (Canadian Council of Ministers of the Environment) Water Quality Guidelines for Livestock Water.

[b] The value provided is the lowest of the NOAEL-based benchmarks for water provided in Table 12 of Sample et al. (1996).

[c] Average measured baseline concentration.

95th P = 95th Percentile; NV = No value; mg/L = miligram per litre

1.1E+00	= Exceeds Background + 10% and Standard
9.3E-01	= Exceeds Standard
8.1E+03	= Exceeds Background + 10%

Table B-4: Comparison of Predicted Sediment Concentrations to Guidelines and Baseline Concentrations

Chemical	Units	CCME Soil Guidelines (mg/kg)[a]	U.S. EPA- Ecological Soil Screening Levels (mg/kg)		Nico Lake			Peanut lake			Burke Lake		
Total Metals			Mammalian[d]	Avian[e]	Baseline Sediment Concentrations	Baseline + 10%[f]	Predicted Sediment Concentrations at Closure[g]	Baseline Sediment Concentrations	Baseline + 10%[f]	Predicted Sediment Concentrations at Closure[g]	Baseline Sediment Concentrations	Baseline + 10%[f]	Predicted Sediment Concentrations at Closure[g]
Aluminum (Al)	mg/kg	NV	NV	NV	-	-	NA	-	-	NA	-	-	NA
Antimony (Sb)	mg/kg	NV	0.27	NV	0.4	0.44	**2.58**	0.35	0.385	**0.50**	0.2	0.22	**0.42**
Arsenic (As)	mg/kg	17.00	46	43	482	530.2	**1,090**	47	51.7	**82**	24	26.4	**40.8**
Barium (Ba)	mg/kg	NV	2000	NV	119	130.35	240.93	194.5	213.95	224.71	228	250.8	317.49
Beryllium (Be)	mg/kg	4[c]	21	NV	1	1.1	1.70	1	1.1	1.01	1	1.1	1.00
Cadmium (Cd)	mg/kg	10	0.36	0.77	0.5	0.55	**0.53**	0.5	0.55	**0.51**	0.5	0.55	**0.50**
Chromium (Cr)	mg/kg	64[b]	34	26	38	41.8	**45.30**	72	79.2	**73.30**	71	78.1	**82.9**
Cobalt (Co)	mg/kg	50[c]	230	120	70	77	54.62	19.5	21.45	26.36	15.5	17.05	20.42
Copper (Cu)	mg/kg	63	49	28	208.5	229.35	**65.20**	35.5	39.05	**43.8**	34	37.4	**42.2**
Iron (Fe)	mg/kg	NV	NV	NV	24333	26766.3	NA	32667	35933.7	NA	30766.5	33843.15	NA
Lead (Pb)	mg/kg	300	56	11	7.1	7.81	9.09	11.85	13.035	**11.94**	10.5	11.55	**12**
Manganese (Mn)	mg/kg	NV	4000	4300	268.06	294.866	NA	446.33	490.963	NA	323.5	355.85	NA
Mercury (Hg)	mg/kg	12	NV	NV	0.09	0.099	0.10	0.05	0.055	0.07	0.05	0.055	0.06
Molybdenum (Mo)	mg/kg	10[c]	NV	NV	6.5	7.15	**12.17**	1.5	1.65	2.02	1	1.1	1.41
Nickel (Ni)	mg/kg	50	130	210	27.5	30.25	31.93	41	45.1	43.70	43	47.3	**50.9**
Selenium (Se)	mg/kg	1	0.63	1.2	1.2	1.32	**1.02**	0.3	0.33	**0.69**	0.2	0.22	0.59
Silver (Ag)	mg/kg	20[c]	14	4.2	1	1.1	<1	1	1.1	<1	1	1.1	<1
Thallium (Tl)	mg/kg	1.4	NV	NV	1	1.1	<1	1	1.1	<1	1	1.1	<1
Uranium (U)	mg/kg	500	NV	NV	17.5	19.25	17.86	8	8.8	7.98	7.5	8.25	8.99
Vanadium (V)	mg/kg	130[c]	280	7.8	35.5	39.05	**70.2**	59	64.9	**62.72**	61.5	67.65	**71.9**
Zinc (Zn)	mg/kg	200[c]	79	46	135.0	148.5	**189**	251.5	276.65	**159**	100	110	**140**

[a] CCME (Canadian Council of Ministers of the Environment) Soil Quality Guidelines for the Protection of Environmental Health - Residential/Parkland.
[b] Guideline for total chromium
[c] SQG_{HH} (CCME Soil Quality Guideline for the Protection of Human Health - Residential/Parkland).
[d] U.S. EPA ECO-SSL (Ecological Screening Level) for Mammalian Wildlife.
[e] U.S. EPA ECO-SSL for Avian Wildlife.
[f] Average measured baseline concentration plus 10%.
[g] Maximum predicted sediment concentration at closure.

NV = No value; mg/kg = miligram per kilogram

1.1E+00	= Exceeds Background + 10% and Standard
9.3E-01	= Exceeds Standard
8.1E+03	= Exceeds Background + 10%

APPENDIX C

Toxicity Reference Values for Mammals and Birds

Table C-1: Toxicological Reference Values for Mammals

Chemical	Threshold	Value (mg/kg)	Test Species	End Point	Study Length	Exposure Route	Dosage	Source
Antimony	NOAEL	0.125	Mouse	Lifespan, Longevity	Lifetime (>1 yr)	Oral in Water	5 ppm	Sample et al. 1996
	LOAEL	1.25	Mouse	Lifespan, Longevity	Lifetime (>1 yr)	Oral in Water	5 ppm	Sample et al. 1996
Arsenic	NOAEL	0.126	Mouse	Reproduction	3 Generations (>1 yr)	Oral in Water (+ Incidental in Food)	5 mg As/L	Sample et al. 1996
	LOAEL	1.26	Mouse	Reproduction	3 Generations (>1 yr)	Oral in Water (+ Incidental in Food)	5 mg As/L	Sample et al. 1996
Chromium	NOAEL	2.4[a]	Multiple	Reproduction, Growth	Variable	Multiple	Multiple	U.S. EPA 2010, internet site
	LOAEL	NV	-	-	-	-	-	-
Copper	NOAEL	5.6[b]	Multiple	Reproduction, Growth	Variable	Multiple	Multiple	U.S. EPA 2010, internet site
	LOAEL	15.14	Mink	Reproduction	357 days	Oral in Diet	25, 50, 100, and 200 ppm Cu + 60.5 ppm Cu in base feed	Sample et al. 1996
Lead	NOAEL	4.7[c]	Multiple	Growth, Reproduction, or Survival	Variable	Multiple	Multiple	U.S. EPA 2010, internet site
	LOAEL	80	Rat	Reproduction	3 Generations (>1 yr)	Oral in Diet	10, 50, 100, 1000, and 2000 ppm Pb	Sample et al. 1996
Molybdenum	NOAEL	0.26	Mouse	Reproduction	3 Generations (>1 yr)	Oral in Water	10 mg Mo/L + 0.45 mg/kg in diet	Sample et al. 1996
	LOAEL	2.6	Mouse	Reproduction	3 Generations (>1 yr)	Oral in Water	10 mg Mo/L + 0.45 mg/kg in diet	Sample et al. 1996
Selenium	NOAEL	0.143[d]	Multiple	Growth, Reproduction, or Survival	Variable	Multiple	Multiple	U.S. EPA 2010, internet site
	LOAEL	0.33	Rat	Reproduction	1 yr (through 2 generations)	Oral in Water	1.5, 2.5, and 7.5 Se/L	Sample et al. 1996
Vanadium	NOAEL	4.16[e]	Multiple	Growth, Reproduction, or Survival	Variable	Multiple	Multiple	U.S. EPA 2010, internet site
	LOAEL	2.1	Rat	Reproduction	60 d prior to gestation, plus through gestation, delivery, and lactation	Oral Intubation	5, 10, and 20 mg $NaVO_3$/kg/d	Sample et al. 1996
Zinc	NOAEL	75.4[f]	Multiple	Growth, Reproduction	Variable	Multiple	Multiple	U.S. EPA 2010, internet site
	LOAEL	320	Rat	Reproduction	Days 1-16 of Gestation	Oral in Diet	2000, and 4000 ppm Zn	Sample et al. 1996

Notes:

[a] The Eco-SSL for chromium (III) is the geometric mean of the NOAEL values for reproduction and growth for the rat, mouse, pig, and cattle.

[b] The Eco-SSL for copper is the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival for the mink, pig, mouse, rat, cattle, guinea pig, rabbit, horse (Shetland pony, common shrew, goat, an sheep.

[c] The Eco-SSL for lead is the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival for the rat, sheep, guinea pig, cotton Rat, hamster, mouse, cattle, dog, and the rabbit.

[d] The Eco-SSL for selenium is the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival for the mouse, rat, cattle, sheep, pig, rabbit, hamster, dog, and the goat.

[e] The Eco-SSL for vanadium is the highest bounded NOAEL below the loest bounded LOAEL for reproduction, growth, or survival for the mouse, rat, sheep, pig and the rabbit.

[f] The Eco-SSL for zinc if the geometric mean of the NOAEL values for reproduction and growth for the pig, mouse, rat, rabbit, hamster, water buffalo, cattle, mink and the sheep.

NV = No value.

Table C-2: Toxicological Reference Values for Birds

Chemical	Threshold	Value (mg/kg/d)	Test Species	End Point	Study Length	Exposure Route	Dosage	Source
Antimony	NOAEL	NV	-	-	-	-	-	-
	LOAEL	NV	-	-	-	-	-	-
Arsenic	NOAEL	2.24[a]	Multiple	Growth, Reproduction, or Survival	Variable	Oral in Diet	Multiple	U.S. EPA 2010, internet site
	LOAEL	12.84	Mallard Duck	Mortality	128 Days	Oral in Diet	100, 250, 500, and 1000 ppm Sodium Arsenite	Sample et al. 1996
Chromium	NOAEL	2.66[b]	Multiple	Growth, Reproduction, or Survival	Variable	Oral in Diet	Multiple	U.S. EPA 2010, internet site
	LOAEL	5	Black Duck	Reproduction	10 Month	Oral in Diet	10 and 50 ppm Cr^{+3}	Sample et al. 1996
Copper	NOAEL	4.05[c]	Multiple	Growth, Reproduction, or Survival	Variable	Multiple	Multiple	U.S. EPA 2010, internet site
	LOAEL	61.7	1 Day Old Chicks	Growth, Mortality	10 Weeks	Oral in Diet	36.8, 52.0, 73.5, 104.0, 147.1, 208.0, 294.1, 403, 570, 749, and 1180 ppm total Cu	Sample et al. 1996
Lead	NOAEL	1.63[d]	Multiple	Growth, Reproduction, or Survival	Variable	Multiple	Multiple	U.S. EPA 2010, internet site
	LOAEL	11.3	Japanese Quail	Reproduction	12 Weeks	Oral in Diet	1, 10, 100, and 1000 ppm Pb	Sample et al. 1996
Molybdenum	NOAEL	3.5	Chicken	Reproduction	21 Days Through Reproduction	Oral in Diet	500, 1000, and 2000 ppm MO	Sample et al. 1996
	LOAEL	35.3	Chicken	Reproduction	21 Days Through Reproduction	Oral in Diet	500, 1000, and 2000 ppm MO	Sample et al. 1996
Selenium	NOAEL	0.29[e]	Multiple	Growth, Reproduction, or Survival	Variable	Oral in Diet	Multiple	U.S. EPA 2010, internet site
	LOAEL	0.8	Mallard Duck	Reproduction	100 Days	Oral in Diet	1, 2, 4, 8, and 16 ppm Se	Sample et al. 1996
Vanadium	NOAEL	0.344[f]	Multiple	Growth, Reproduction, or Survival	Variable	Oral in Diet	Multiple	U.S. EPA 2010, internet site
	LOAEL	NV	-	-	-	-	-	-
Zinc	NOAEL	66.1[g]	Multiple	Growth, Reproduction	Variable	Oral in Diet	Multiple	U.S. EPA 2010, internet site
	LOAEL	131[h]	White Leghorn Hens	Reproduction	44 weeks	Oral in Diet	20, 200, and 2000 supplimental Zn + 28 ppm in diet	Hill 1979

Notes:

[a] The Eco-SSL for arsenic is the Lowest NOAEL value for reproduction, growth, and survival for the chicken or mallard duck

[b] The Eco- SSL for chromium (III) is the geometric mean of the NOAEL values for reproductiom and growth for the chicken, black duck, and turkey.

[c] The Eco-SSL for copper is the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth or survival for the chicken, turkey, duck, and Japanese quail.

[d] The ECO-SSL for lead is the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival for the Japanese quail, chicken, malllard duck, American kestrel, ringed turtle dove, pigeon, and the goose.

[e] The Eco-SSL for selenium is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth or survival for the chicken, mallard duck, Japanese quail, American kestrel, Bback-crowned night-heron, and the owl.

[f] The Eco-SSL for vanadium is the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival for the chicken, Japanese quail, and the duck.

[g] The Eco-SSL for vanadium is the geometric mean of the NOAEL values for growth and reproduction for the chicken, mallard duck, Japanese quail, and the turkey

[h] An avian LOAEL for vanadium was not provided in the Eco-SSL Guidance Document, (U.S.EPA 2005a). However, the avian NOAEL TRV for vanadium was selected from a study by Hill (1979), examining the growth effects on chickens and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction , growth and survival endpoints. The LOAEL TRV of 0.688 mg/kg-bw/day is the bounded value from the same study and is used as the LOAEL for vanadium for the WHRA.

NV = No value.

DEVELOPER'S ASSESSMENT REPORT

Fortune Minerals Limited
140 Fullarton Street
Suite 1902
London, Ontario, N6A 5P2
Canada
T: +1 (519) 858 8188

Golder Associates Ltd.
#300, 10525-170 St.,
Edmonton, Alberta, T5P 4W2
Canada
T: +1 (780) 483 3499

Golder Associates

FORTUNE MINERALS LIMITED