HUMAN AND WILDLIFE HEALTH RISK ASSESSMENT REPORT FOR THE JAY PROJECT

Prepared for: Dominion Diamond Ekati Corporation

Prepared by: Golder Associates Ltd.

February 2015

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DOMINION DIAMOND

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DOMINION DIAMOND

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Abbreviations

Abbreviation	Definition
ATSDR	Agency of Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BCF	bioconcentration factor
BTF	biotransfer factor
CCME	Canadian Council of Ministers of the Environment
COPC	constituent of potential concern
DAR	Developer's Assessment Report
e.g.	for example
Eco-SSL	Ecological Soil Screening Levels
EDI	estimated daily intake
ESA	effects study area
HQ	hazard quotient
HWHRA	human and wildlife health risk assessment
i.e.	that is
ILCR	incremental lifetime cancer risk
IUR	inhalation unit risk
KLOI	Key Lines of Inquiry
L	litres
LDG	Lac de Gras
LOAEL	lowest observed adverse effect level
MPOI	maximum point of impingement
NOAEL	no-observed-adverse-effect level
NWT	Northwest Territories
OMOE	Ontario Ministry of the Environment
PAH	polycyclic aromatic hydrocarbon
PM	particulate matter
PM_{10}	particulate matter with a mean aerodynamic diameter of 10 microns or smaller
$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller
RfD	reference dose
RFD	Reasonably Foreseeable Development
SF	slope factor
TK	Traditional Knowledge
TOR	Terms of Reference
TRV	toxicological reference value
UCLM	upper confidence limit on the mean
US EPA	United States Environmental Protection Agency
US NAAQS	United States National Ambient Air Quality Standards
VC	valued component
VOC	volatile organic compound
WHO	World Health Organization

Units of Measure

Unit	Definition
<	less than
km	kilometre
$\mu g/m^3$	micrograms per cubic metre
mg/kg BW/day	milligrams per kilogram of body weight per day

1 INTRODUCTION

1.1 Background

The existing Dominion Diamond Ekati Corporation (Dominion Diamond) Ekati Diamond Mine (Ekati Mine) and its surrounding claim block are located approximately 300 kilometres (km) northeast of Yellowknife in the Northwest Territories (NWT) (Map 1.1-1). Dominion Diamond proposes to develop the Jay Project (Project), which includes the Jay Pit, along with associated mining and transportation infrastructure (Map 1.1-2) to add 10 or more years of operations life to the Ekati Mine. The majority of the facilities required to support the Project and process the kimberlite already exist at the Ekati Mine, including:

- Misery Pit mining infrastructure (e.g., fuel facility, explosives magazines);
- primary roads and transportation infrastructure (e.g., Ekati airstrip, Misery Road);
- Ekati main camp and supporting infrastructure;
- Ekati processing plant; and,
- fine processed kimberlite management facilities.

The Jay kimberlite pipe is located beneath Lac du Sauvage in the southeastern portion of the Ekati claim block, approximately 7 km to the northeast of the Misery Pit (Map 1.1-2). A horseshoe-shaped dike will be constructed to isolate the portion of Lac du Sauvage overlying the Jay kimberlite pipe. The isolated portion of Lac du Sauvage will be dewatered to allow for open-pit mining of the kimberlite pipe.
The Project will also require an access road, pipelines, and power lines to the new open pit. The following activities associated with the proposed Jay Project description are particularly relevant to human and wildlife health:

- fugitive dust and air emissions;
- open-pit mining of the Jay Pit;
- waste rock and processed kimberlite storage;
- management of minewater within the site;
- release of operational minewater from the Misery Pit to Lac du Sauvage via a diffuser, starting after Year 5 of mining; and,
- other activities that will affect the quantity and quality of water in Lac de Gras and Lac du Sauvage in the vicinity of the Project.

The potential effects of the proposed Project on human and wildlife health within the effects study area (ESA) are addressed in detail within this report. This includes the following assessment components:

- an acute and chronic air inhalation assessment (human health only);
- an assessment of exposure to airborne particulate matter (human health only);
- a multimedia assessment of potential chronic effects on human health that includes consumption of country foods[1] (e.g., fish, game, and berries); and,
- A multimedia assessment of potential chronic effects on wildlife health from changes to the food supply and food chain.

The Project activities listed above have the potential to result in effects on human and wildlife health and have been included in the assessment of effects.

Additional details on Project activities with pathways to potential effects on human and wildlife health are provided in Section 3.

1.2 Purpose and Scope

The purpose of this report is to report in full detail on the assessment of the significance of incremental and cumulative chemical emissions from the Project and other developments on human and wildlife health. The Terms of Reference (TOR) issued by the Mackenzie Valley Environmental Impact Review Board (MVEIRB) for the Jay Project includes human health and four wildlife components (caribou, carnivores, breeding birds, and species at risk) as valued components (VCs) for the assessment. The results of the Human and Wildlife Health Risk Assessment were reported and incorporated into the Developer's Assessment Report for the Jay Project that was submitted in November 2014. This report provides the full detail behind those results.

The following two Key Lines of Inquiry (KLOIs) relevant to human and wildlife health were identified in the TOR:

- KLOI-3. Impacts to caribou; and,
- KLOI-5. Maximizing benefits and minimizing impacts to communities.

Subjects of Note relevant to human and wildlife health included:

- Impacts to wildlife and wildlife habitat from project components.

[1] Country foods are dietary items from the local region that are used for sustenance. Country food items include fruit, vegetables, herbs, medicinal plants, fish, and game.

The objective of the human and wildlife health risk assessment is to evaluate the potential human health and ecological risks that would be posed by the proposed Project. The assessment considered the effects of chemical emissions from routine activities on the receiving environment (e.g., soil, food, water, sediment, and air quality) and how they may affect human and wildlife health. Consistent with the items described in the TOR, the assessment of potential human health impacts includes potential effects on and from traditional harvesting activities of Aboriginal residents as part of the assessment components listed in Section 1.1. The ecological risk assessment of this component focuses on birds and mammals in the study area; an aquatic health assessment was included in Section 8.5.5 of the Developer's Assessment Report (DAR). With respect to wildlife health, effects on caribou were assessed along with effects on other wildlife. For caribou and the other wildlife receptors identified, the assessment considers the potential for bioaccumulation of contaminants from relevant sources within the food chain.

LEGEND

- JAY PROJECT
- EXISTING MINE OR PROJECT
- TERRITORIAL CAPITAL
- POPULATED PLACE
- HIGHWAY
- ALL-SEASON ROAD
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- TERRITORIAL/PROVINCIAL BOUNDARY
- TREELINE
- WATERCOURSE
- WATERBODY
- EKATI CLAIM BLOCK

150 0 150

SCALE 1:6,000,000 KILOMETRES

REFERENCE

WATER OBTAINED FROM ATLAS OF CANADA
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
PROJECTION: CANADA LAMBERT CONFORMAL CONIC

DOCUMENT

HUMAN AND WILDLIFE HEALTH RISK ASSESSMENT

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

LOCATION OF EKATI CLAIM BLOCK

Golder Associates

PROJECT		1407256	FILE No. PDAR_Gen_001_GIS	
DESIGN	SK	26/01/15	SCALE AS SHOWN	REV. 0
GIS	LMS	30/01/15	MAP 1.1-1	
CHECK	SK	30/01/15		
REVIEW	RS	30/01/15		

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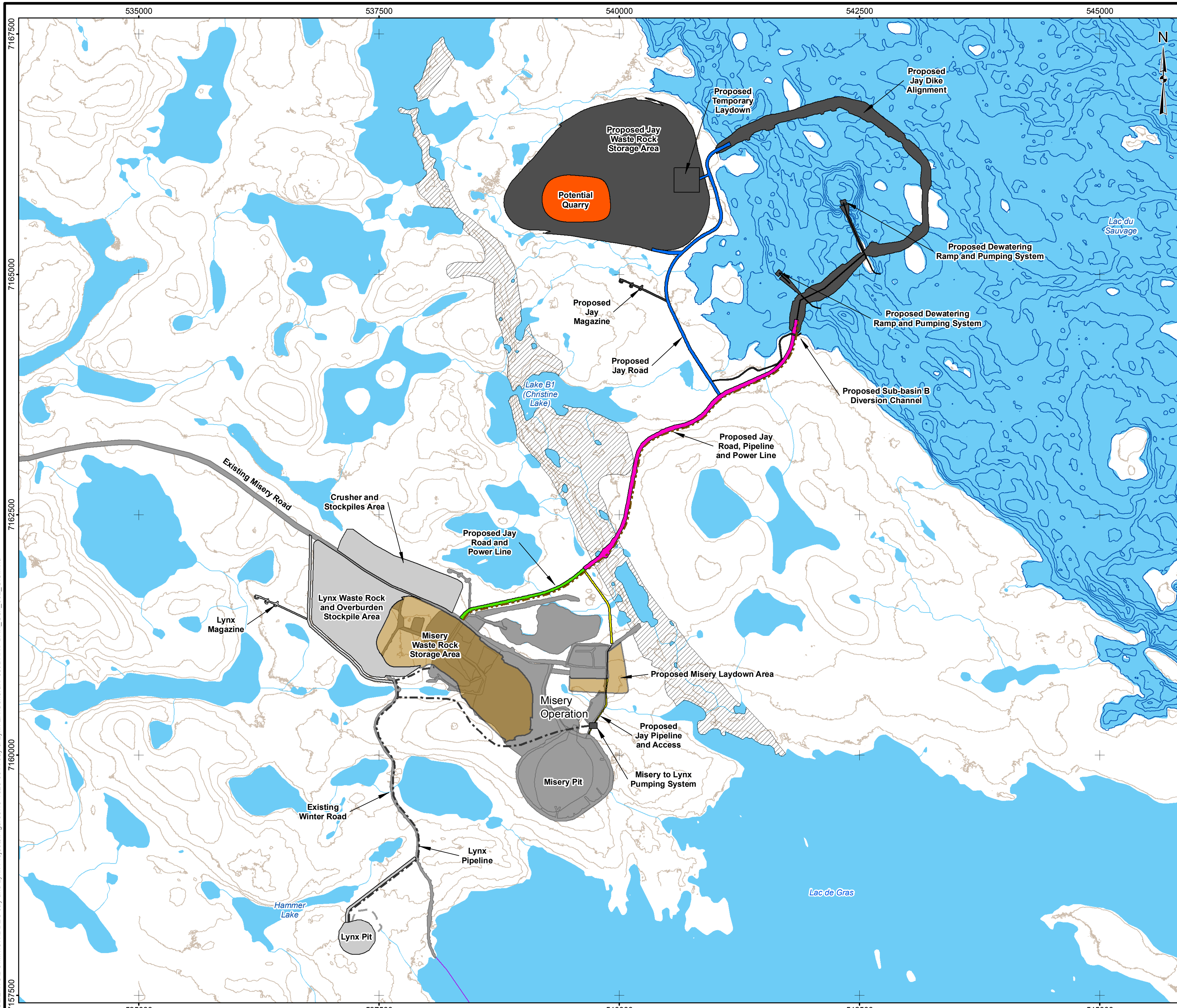

LEGEND

- EKATI MINE FOOTPRINT (MISERY OPERATION)
- WINTER ROAD
- BATHYMETRY CONTOUR (5 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- ESKER

JAY PROJECT FOOTPRINT

- POWER LINE
- PROPOSED JAY PROJECT INFRASTRUCTURE
- PROPOSED JAY ROAD NORTH (HAUL ROAD)
- PROPOSED JAY ROAD (HAUL ROAD AND POWER LINE)
- PROPOSED JAY ROAD (HAUL ROAD, PIPELINE AND POWER LINE)
- PROPOSED JAY PIPELINE ROAD (ACCESS ROAD AND PIPELINE)
- POTENTIAL QUARRY

LYNX PROJECT FOOTPRINT

- EXISTING SHORELINE OF DEWATERED LYNX LAKE
- LYNX PIPELINE
- LYNX PROJECT INFRASTRUCTURE

MISERY PROJECT FOOTPRINT EXPANSION

- MISERY PROJECT INFRASTRUCTURE

NOTES

ROAD, PIPELINES, AND POWER LINE ARRANGEMENT TO BE DETAILED AS PART OF PRE-FEASIBILITY DESIGN. APPROXIMATE CORRIDOR WIDTHS ARE SHOWN. POTENTIAL QUARRY MAY BE REQUIRED WITHIN THE FOOTPRINT OF THE PROPOSED JAY WASTE ROCK STORAGE AREA

REFERENCE

JAY PROJECT CONCEPTUAL ENGINEERING REPORT, EKATI MINE, DOC#: 1313280041-E14037-R-REV0-4060, DATED: MAY 13, 2014
JAY PROJECT DESIGN BASIS MEMORANDUM FOR PRE-FEASIBILITY DESIGN OF PROJECT ROADS AND PIPELINE BENCHES, DOC#: 1313280041-E14031-TM-REVD-2020, DATED: AUGUST 1, 2014
LIDAR AND BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
WATER OBTAINED FROM CANVEC © NATURAL RESOURCES CANADA, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

HUMAN AND WILDLIFE HEALTH RISK ASSESSMENT

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

JAY PROJECT MINING AND TRANSPORTATION INFRASTRUCTURE

Golder Associates

PROJECT		1407256	FILE No. PDAR_Gen_002_GIS	
DESIGN	SK	26/01/15	SCALE AS SHOWN	REV 0
GIS	LMS	30/01/15		
CHECK	SK	30/01/15	MAP 1.1-2	
REVIEW	RS	30/01/15		

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1.3 Valued Components

Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered important to society. Valued components selected for use in the assessment of the Project on human and wildlife health are presented in Table 1.3-1 and are discussed in more detail below.

1.3.1 Human Health

People are the VC for the human health risk assessment. The human health risk assessment focused on locations where people are known to be present (e.g., hunting camps and work sites). The assessment also considered the unique diets and lifestyles of Aboriginal residents in the region, including the reliance on wild plants and animals as food sources.

1.3.2 Wildlife Health

The TOR included a preliminary listing of valued components relevant to wildlife health, including:

- caribou and caribou habitat;
- carnivores (wolverine, grizzly bears, wolves);
- breeding birds; and,
- species at risk.

This section expands on these VCs to provide a detailed list of functional groups and representative species to represent the avian and mammalian wildlife communities feeding in both terrestrial and aquatic habitats. A functioning ecosystem involves interactions of multiple species, ranging in size and complexity from bacteria to apex wildlife predators. Each species is likely to respond differently to levels of substances present in environmental media. Because it is not possible to directly assess the risk for each individual species, it is necessary to simplify the complex ecosystem into organism groups and trophic linkages. The general ecology of the Project area was reviewed based on existing information, and the wildlife species present were divided into major ecosystem components (e.g., terrestrial and aquatic mammalian/avian invertivores, mammalian/avian herbivores). Representative taxa (referred to as wildlife receptors) were then selected as surrogates for each ecosystem component, and are listed in Table 1.3-1. The representative receptor taxa were selected from those that are documented or anticipated to occur or potentially occur in the ESA, have a relatively high potential for exposure to potentially exposed media, and play a key role in the food web, and for which sufficient data were available to facilitate calculations of exposures and risks.

In Table 1.3-1, the carnivores as listed above were grouped as “large carnivores.” Other mammals inhabiting representative niches of the aquatic and terrestrial foodwebs were grouped as “other mammals. Caribou and breeding birds were retained as overall groups for these species, and species at risk are identified (i.e., underlined in Table 1.3-1) within each grouping.

The receptor species listed in Table 1.3-1 encompass the potential range of aquatic and terrestrial wildlife habitats within the ESA. An initial screening step was applied to determine the habitats where changes in contaminant concentrations were predicted. For receptors feeding in these habitats where changes were predicted, a multimedia risk assessment was conducted. Risks calculated for each receptor in the multimedia assessment were interpreted as applying to all members of each valued component (VC).

Table 1.3-1 Rationale for Selection of Human Health and Wildlife Health Valued Components

Valued Component	Ecological Niche	Rationale for Selection
People		
People	n/a	Human health risk assessment is focused on the assessment of people.
Caribou		
Barren-ground Caribou	Terrestrial herbivore	• Barren-ground caribou are an important cultural and economic resource for people in the NWT, and were identified as a Key Line of Inquiry in the Terms of Reference for the Project. • Barren-ground caribou occupy a large-herbivore niche in the terrestrial environment, feeding on lichen and other vegetation. Health assessment results for this species indicate potential terrestrial effects of the Project that are applicable to caribou and other large ungulate herbivores.
Large Carnivores		
Grizzly bear	Aquatic/Terrestrial Omnivore	• Carnivores and Species at Risk, including grizzly bear, were identified as a Subject of Note in the Terms of Reference for the Project. • Grizzly bears are omnivorous, feeding on a combination of caribou, small mammals, aquatic and terrestrial vegetation, and fish. Health assessment results for this species indicate the potential for combined terrestrial and aquatic effects on large omnivores. The grizzly bear is listed as a species of Special Concern by COSEWIC.
Wolverine	Terrestrial Carnivore	• Carnivores and Species at Risk, including wolverine, were identified as a Subject of Note in the Terms of Reference. • Wolverines are primarily carnivorous, feeding on large game such as caribou and small birds and mammals. Health assessment results for this species indicate the potential for terrestrial effects on carnivores. Wolverines are listed as a species of Special Concern by COSEWIC.
Gray wolf	Terrestrial Carnivore	• Carnivores, including wolves were identified as a Subject of Note in the Terms of Reference for the Project. • Wolves are primarily carnivorous, feeding on large game such as caribou and small birds and mammals. Health assessment results for this species indicate the potential terrestrial effects on carnivores.
Other Mammals		
Barren ground shrew	Terrestrial Insectivore	• The barren ground shrew represents small mammals in the terrestrial food chain. The barren-ground shrew feeds primarily on invertebrates on and in soils, and therefore is closely connected to Project effects on terrestrial soils.
Meadow vole	Terrestrial Herbivore	• The meadow vole represents small mammals in the terrestrial food chain. Meadow voles feed primarily on terrestrial vegetation, and therefore are closely connected to Project effects related to terrestrial vegetation.
Musk oxen	Terrestrial Herbivore	• Musk oxen represent large herbivores in the terrestrial food chain. Musk oxen feed primarily on terrestrial vegetation, and therefore are closely connected to Project effects related to terrestrial vegetation.

Table 1.3-1 Rationale for Selection of Human Health and Wildlife Health Valued Components

Valued Component	Ecological Niche	Rationale for Selection
Moose	Aquatic/Terrestrial Herbivore	• Moose represents large herbivores in the aquatic/terrestrial food chain. Moose feed on aquatic and terrestrial vegetation, and therefore are connected to combined Project effects on aquatic and terrestrial vegetation.
Acetic fox	Terrestrial Carnivore	• Arctic fox represent medium-sized carnivores in the terrestrial food chain. Arctic fox feed primarily on small mammals, and therefore are closely connected to Project effects on the terrestrial food chain.
Muskrat	Aquatic Omnivore	• Muskrat represents small mammals in the aquatic food chain. Muskrat feed primarily on aquatic plants, supplemented with aquatic invertebrates and fish, and some terrestrial vegetation. The muskrat is closely connected to Project effects on aquatic habitats and food sources.
Breeding Birds		
American robin	Terrestrial Invertivore	• Breeding birds were identified as a Subject of Note in the Terms of Reference for the Project. • American robins may migrate and breed in the ESA, and feed primarily on invertebrates on and in soils. Therefore, the American robin is closely connected to Project effects on terrestrial soils.
Willow ptarmigan	Terrestrial Herbivore	• Breeding birds were identified as a Subject of Note in the Terms of Reference for the Project. • Willow ptarmigans may migrate or be resident in the ESA, and are herbivores, feeding on a variety of terrestrial vegetation. The willow ptarmigan is connected to Project effects on terrestrial habitats.
Common raven	Terrestrial Omnivore	• Breeding birds were identified as a Subject of Note in the Terms of Reference for the Project. • Common ravens may migrate or be resident in the ESA, and are opportunistic omnivores feeding on a variety of terrestrial food items. The common raven is connected to Project effects on terrestrial habitats.
Short-eared owl	Terrestrial Carnivore	• Breeding birds and Species at Risk were identified as a Subject of Note in the Terms of Reference. • Short-eared owls may migrate and breed in the ESA. Short-eared owls are primarily carnivorous, feeding on a variety of rodents and occasionally small birds. Health assessment results for this species indicate the potential terrestrial effects on avian carnivores. Short-eared owls are listed as a species of Special Concern by COSEWIC.
Peregrine Falcon	Terrestrial Carnivore	• Breeding birds and Species at Risk were identified as a Subject of Note in the Terms of Reference. • Peregrine falcons may migrate and breed in the ESA. Peregrine falcons are primarily carnivorous, feeding on a variety of birds and occasionally on small mammals. Peregrine falcons are listed as a species of Special Concern by COSEWIC.
Green-winged teal	Aquatic Herbivore	• Breeding birds were identified as a Subject of Note in the Terms of Reference for the Project. • Green-winged teal may migrate and breed in the ESA, and feed primarily on aquatic vegetation and, occasionally aquatic invertebrates. Therefore, green-winged teal are closely connected to Project effects on aquatic habitats.

Table 1.3-1 Rationale for Selection of Human Health and Wildlife Health Valued Components

Valued Component	Ecological Niche	Rationale for Selection
Semi-palmated sandpiper	Aquatic Insectivore	• Breeding birds were identified as a Subject of Note in the Terms of Reference for the Project. • Semi-palmated sandpipers may migrate and breed in the ESA, and feed primarily on aquatic invertebrates. The semi-palmated sandpiper is closely connected to Project effects on aquatic habitats.
Rusty blackbird	Aquatic/Terrestrial Omnivore	• Breeding birds and Species at Risk were identified as a Subject of Note in the Terms of Reference for the Project. • Rusty blackbirds may migrate and breed in the ESA, and are omnivorous, feeding on aquatic invertebrates, fish, and terrestrial vegetation. Therefore, rusty blackbirds are closely connected to combined Project effects on aquatic and terrestrial habitats. Rusty blackbirds are listed as a species of Special Concern by COSEWIC.
Common merganser	Aquatic Omnivore	• Breeding birds were identified as a Subject of Note in the Terms of Reference for the Project. • Common mergansers may migrate and breed in the ESA, and feed a combination of aquatic invertebrates, fish, and aquatic plants. Therefore, the Common merganser is closely connected to Project effects on aquatic habitats.
Bald eagle	Aquatic/Terrestrial Carnivore	• Breeding birds were identified as a Subject of Note in the Terms of Reference for the Project. • Bald eagles may migrate and breed in the ESA, and are opportunistic predators, consuming fish, small mammals, birds, and carrion. Bald eagles are closely connected to combined Project effects on terrestrial and aquatic habitats.

Note: Underlined – Threatened, Endangered or Special Concern.
Information sources for wildlife include:
Birds of North America Online (Poole 2005);
NWT Species at Risk (Government of NWT 2015); and,
NatureServe Explorer (NatureServe 2015).
NWT = Northwest Territories; ESA = effects study area; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; n/a = not applicable.

1.4 Assessment and Measurement Endpoints

Assessment endpoints are qualitative expressions that represent the key issues of concern with respect to the potential effects of the Project and are used to evaluate effects on a VC. The assessment endpoints used in the human and wildlife health risk assessment are provided in Table 1.4-1.

Measurement indicators represent properties or attributes of the environment, which when changed or affected by the Project, could result in or contribute to an effect on an assessment endpoint. Measurement endpoints may be quantitative or qualitative and either be based on direct measurements of the environment or integration of multiple changes of the environment. In the case of risk assessment for human health and wildlife health the measurement indicators consist primarily of hazard quotients (refer to Section 1.7.4 for further discussion) and incremental lifetime cancer risks. The measurement indicators for the human and wildlife health risk assessment are also outlined in Table 1.4-1.

Table 1.4-1 Valued Components, Assessment Endpoints, and Measurement Endpoints

Valued Component	Assessment Endpoints	Measurement Indicators
People	Protection of human health from adverse acute or chronic health effects, and from cancer.	• Hazard quotients for non-carcinogens • Incremental lifetime cancer risk for carcinogens • Qualitative literature assessment for particulate matter
Wildlife Caribou Large Carnivores Other Mammals Breeding Birds	Protection of wildlife health from adverse chronic and acute effects.	• Chronic hazard quotient based on multimedia assessment • Screening of acute exposure pathways.

1.5 Spatial Boundaries

The Project is situated in the southeastern portion of the Ekati Mine property approximately 25 km from the main facilities at the Ekati Mine and approximately 7 km to the northeast of the existing Misery Pit. The existing Diavik Diamond Mine (Diavik Mine) is approximately 6 km south-southwest of the Misery Pit (Map 1.5-1). The Project site is approximately 150 km east of the nearest community, Wekweètì, and 200 km northeast of Yellowknife (Map 1.1-1).

Because the human and wildlife health risk assessment integrates information from the water quality, air quality, aquatic health, wildlife, traditional land use, and socio-economics disciplines, the ESA was developed considering the spatial boundaries for these other disciplines.

LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- PROPOSED JAY FOOTPRINT
- KIMBERLITE PIPE
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- ESKER
- WATERCOURSE
- WATERBODY

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

HUMAN AND WILDLIFE HEALTH RISK ASSESSMENT

3.5 0 3.5
SCALE 1:175,000 KILOMETRES

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

EKATI MINE, JAY KIMBERLITE PIPE AND DIAVIK MINE

Golder Associates

PROJECT		1407256	FILE No. PDAR_Gen_003_GIS	
DESIGN	SK	26/01/15	SCALE AS SHOWN	REV 0
GIS	LMS	30/01/15	MAP 1.5-1	
CHECK	SK	30/01/15		
REVIEW	KM	30/01/15		

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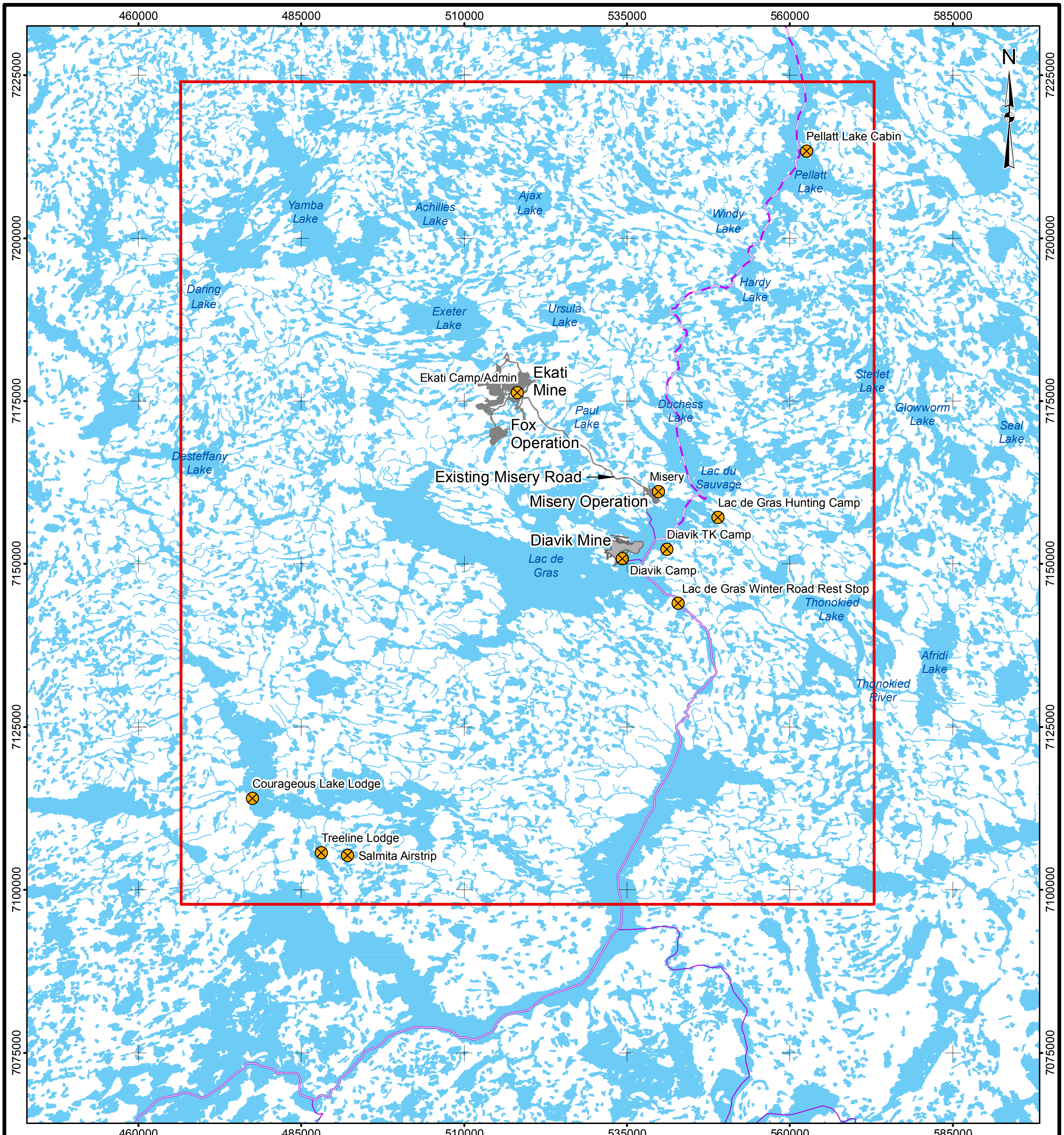
Map 1.5-2 presents the ESA for the human and wildlife health risk assessment (HWHRA). The ESA encompasses all of the human receptor locations, Ekati Mine, Diavik Mine, Misery Pit, and the Jay Project. The Project fenceline (located at the boundary between the Project and the ESA) and the maximum point of impingement (MPOI) would be included within the ESA; however, the MPOI is not a fixed location. The MPOI is a hypothetical “worst-case” location outside the mine site area based on the air quality and deposition predictions and varies on a chemical-specific basis. Baseline vegetation and soil samples to support the HWHRA were collected within the ESA, and sampling effort focused on an area in proximity (within 30 km) of the proposed mine footprint, including around Lac du Sauvage and north and east of Lac de Gras (refer to Appendix A). Effects on human health were evaluated on a regional basis. The human health risk ESA was developed by considering the air quality modelling domain, and information about receptor locations identified in consultation with the Traditional Land Use and Socio-Economics teams. Specific receptor locations have been selected for inclusion in the risk assessment, as indicated on Map 1.5-2. The wildlife health risk effects study area was developed by taking into account the air quality, water quality, fish, caribou, and wildlife ESAs. Some wildlife species, including caribou, range much wider than the air quality and water quality ESAs but their range includes the ESA for the human and wildlife health risk assessment. For assessing wildlife health risks, it has been assumed that wildlife would inhabit areas with worst-case exposure near the Jay Project and within the air quality, water quality, and aquatic health ESAs.

The ESA also includes the two lakes considered most likely to be affected by the Project: Lac de Gras and Lac du Sauvage. These lakes are both located in close proximity to the Project footprint water quality predictions focused on potential changes in to water quality in Lac de Gras and Lac du Sauvage. Predicted changes to exposure in the multimedia assessments for human health and wildlife health considered the changes predicted for these two lakes.



LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- WATERCOURSE
- WATERBODY
- RECEPTOR LOCATION
- EFFECTS STUDY AREA

15 0 15

SCALE 1:850,000 KILOMETRES

REFERENCE

NATIONAL TOPOGRAPHIC BASE DATA (NTDB) 1:250,000
CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

HUMAN AND WILDLIFE HEALTH RISK ASSESSMENT

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

EFFECTS STUDY AREA (ESA) AND HUMAN HEALTH RECEPTOR LOCATIONS

Golder Associates

PROJECT		1407256	FILE No. PDAR_Gen_004_GIS	
DESIGN	SK	26/01/15	SCALE AS SHOWN	REV. 0
GIS	JG/LS	30/01/15	MAP 1.5-2	
CHECK	SK	30/01/15		
REVIEW	RS	30/01/15		

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1.6 Temporal Considerations and Assessment Cases

The Project schedule comprises several phases that include:

- construction – (2016 to 2019);
- operations – (2019 to 2029); and,
- closure – (2030 to 2033).

The temporal boundaries adopted for the human and wildlife health risk assessment were based on those applied in the receiving environment water quality model and air dispersion model developed for the Project (by the water and air quality disciplines) because these models provide the main data inputs for the risk assessment models.

With respect to water quality, depth averaged concentrations were predicted for under-ice and open water conditions for Lac du Sauvage as a whole and for three locations in Lac de Gras. Multiple snapshots were predicted including early operations (2019 to 2023), operations (2024 to 2029), closure (2030 to 2033), and post-closure (2034 to 2060). To predict changes in human and wildlife exposure as a result of the Project, the maximum predicted depth-averaged concentration across the waterbodies, locations, and conditions evaluated was chosen to represent the water concentration for exposure modelling. This is a conservative approach, because people and wildlife would be exposed to a range of concentrations over time and across lakes in the ESA and not only the “worst-case” conditions.

The predictions of air quality concentrations and particulate deposition rates were made using the following assumptions and time periods:

- Meteorology data - One year of meteorological data (2002) were used in the dispersion modelling as described in the DAR Section 7.
- Emission rates - The effects on air quality are expected to be greatest when the Project emissions are at the highest. For the Project, the highest emissions will occur during the operations phase. Therefore, the air quality effects assessment focused on 2022, the year with the maximum Project emissions.

The human and wildlife multimedia risk assessment was conducted using representative worst-case predictions from the air quality discipline, including:

- the highest predicted concentrations for air quality and particulate matter;
- the highest location-specific particulate deposition rates among the three receptor locations (Diavik Traditional Knowledge [TK] Camp, Lac de Gras Hunting Camp, and Lac de Gras Winter Road Rest Stop) for the human health multimedia assessment; and,
- the highest particulate deposition rate (typically at the Project fenceline) within the human and wildlife health ESA, for the wildlife health multimedia assessment.

The use of maximum predicted air quality concentrations and deposition rates is conservative because most equipment does not operate at its maximum capacity on a continuous basis.

In applying the deposition rates to predict changes to soil and vegetation, the deposition time considered both the construction and operations phases (a total of 13 years). For the Base Case (described below), the predicted Base Case deposition rate was applied for 13 years to represent baseline conditions in the absence of the Jay Project. For the Application Case, the construction phase deposition rate was applied for three (3) years and the operations phase deposition rate was applied for 10 years. The incremental increase in soil and vegetation concentrations from deposition in each of these phases was summed to determine the overall effect of the Jay Project.

The human health risk assessment evaluated both long-term (chronic) and short-term (acute) effects of chemical exposures on human health. For the long-term assessment, it was assumed that receptors spent their whole lives within the ESA (i.e., up to 80 years), rather than only for the length of the Project. However, the contribution of chemical emissions to existing or natural conditions (e.g., plants and soil) in the region was assumed to occur only for the life of the Project (i.e., 13 years of construction and operations). Exposure durations of 24 hours or less were evaluated in the short-term (acute) exposure air quality assessment and in the particulate matter assessment.

The wildlife health risk assessment evaluated the chronic effects of chemical exposures on wildlife health. Exposures to changes in air quality were not assessed because air and dust inhalation pathway are typically considered negligible relative to the oral ingestion pathway, meaning that inhalation exposure was not considered a direct linkage for wildlife exposure (refer to Table 4.3-2 for additional discussion). Aerial deposition to soil and food items is considered in the wildlife health risk assessment. For the terrestrial wildlife risk assessment, it was also assumed that receptors lived their whole lives within the ESA.

For the human air inhalation assessment, air quality predictions considered in the risk assessment are based on the maximum emissions predicted during the Project (i.e., during construction and operations). The risk estimates provided for the human health air quality risk assessment are reasonable, worst-case estimates of potential health effects as the result of the Project.

For the multimedia risk assessment, air quality predictions and deposition rates are based on the maximum year in each phase (i.e., during construction and operations). Similarly, the maximum depth-averaged water quality predictions from all Project phases and conditions evaluated were used determine health risk estimates for people and wildlife. The risk estimates provided in this effects assessment are reasonable, worst-case estimates of potential effects of the Project on human and wildlife health. Risk estimates are not provided for each phase of the Project (i.e., construction, operations, closure, and post-closure). Instead, the risk estimates provided are assumed to apply over the life of the Project as represented by the Application Case. Deposition during closure and post-closure was not included in the multimedia assessment because the Application Case deposition was based on the highest emission years during construction and operations phases, and deposition typically decreases considerably once mining operations cease.

The human and wildlife health assessment applies a comparative approach that considers multiple cases, depending on the component of the assessment. The air inhalation and particulate matter assessments considered the Base Case, Construction Case, and Application Case. The multimedia human health and wildlife health risk assessments considered the Base Case and Application Case. Each case is described below:

- **Base Case** – The Base Case represents a range of conditions over time within the ESA before application of the Project. The Base Case describes the existing environment prior to the application of the Project, to provide an understanding of the current conditions that may be influenced by the Project. Existing (2015 baseline) conditions include the cumulative effects from the previous and existing developments (i.e., Ekati Mine and Diavik Mine) and activities that are planned and approved (i.e., Lynx Project). Predictions of health risks associated with the Base Case are presented for those parameters that screened into the human and wildlife health risk assessment. These parameters are known as constituents of potential concern (COPCs)[2]. The COPCs are parameters for which the Project was expected to result in a change to environmental concentrations that people and wildlife may be exposed to, and which exceed a health based standard or guideline. The Base Case risk estimates are used to provide context for those generated for the Construction and Application Cases.
- **Construction Case** –The Construction Case represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the construction activities associated with the Project. The Construction Case predictions are based on the Base Case emission profile (Year 2015) plus the maximum emission profile for the construction activities associated with the Project. The Construction Case, on its own, was only considered in the human health air quality and particulate matter assessments. The Construction Case was considered separately from the Application Case (which for air quality was the operations phase of the Project) to evaluate inhalation exposure to air emissions resulting from construction activities. Short-term exposures during construction and operations were evaluated separately, in part as a result of the temporal and spatial variability of chemical concentrations in air, and because of the potential for higher short-term concentrations during different phases of the Project (i.e., construction versus operations). Because the construction phase is expected to last up to three years, the effects of the Construction Case are expected to be temporary relative to the effects during operations (the Application Case for the human health air quality assessment). Assessment of the Construction Case for the human health air quality assessment is consistent with the Air Quality Section of the DAR (Section 7), which also considered the Construction Case.

[2] For the purposes of this assessment, a constituent is defined as a substance evaluated in an environmental medium.

- **Application Case –** The Application Case represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project. The Application Case was also used to identify the incremental changes from the Project that are predicted to occur between the Base and Application cases.
  - *Air Quality and Particulate Matter:* The Application Case for the human health air quality and particulate matter assessments was used to evaluate inhalation exposure to air emissions and particulate matter as a result of the Project during the operations phase. Note that the Construction Case (described above) was considered separately from the operational phase in the Application Case for the air quality and particulate matter assessment only.
  - *Multimedia Assessment:* The Application Case for the human and wildlife health multimedia assessments combined the construction and operations phases presented by the air quality and water quality disciplines (i.e., the cumulative effects of both the construction and operations phases were treated additively in the assessment). The multimedia risks estimated for the Application Case are based on those changes predicted to air, water soil, vegetation, wild game, and aquatic food resources quality that may result from the Project. Construction and operations phases were combined for the multimedia assessment because the effects of deposition would be largely cumulative over time as the Project proceeded through construction and operations. Thus, the Application Case for the multimedia human and wildlife health assessments considered this cumulative effect.

The Reasonably Foreseeable Development Case (RFD Case) considers the cumulative effects of the Project plus any foreseeable future developments in the ESA. The only RFD within the ESA is the Sable project. However, as described in the Jay Project DAR Sable Addendum (Dominion Diamond 2014), potential cumulative changes to water quality in Lac de Gras from the Project and the Sable project in the RFD Case are expected to be similar to those assessed in the DAR. For air quality, the addition of the Sable project may change the spatial distribution of emissions predicted for the Application Case in the DAR, but the overall emissions would be very similar in magnitude because the processing plant operates at fixed capacity. As a result, for the human and wildlife health assessment, the RFD Case was considered to be the same as the Application Case.

To assess the Base Case and Application Case, the human and wildlife health multimedia assessments incorporate data and predictions for water quality and air quality/deposition as well as information on existing populations and the environment determined from the socio-economics, vegetation and wildlife, and aquatic health disciplines. Detailed information regarding how the predictions are incorporated into the human and wildlife risk assessment is provided in Section 4 and in Appendix D to this report.

Cumulative effects are considered at a higher level than the human and wildlife health risk assessment, but any potential effects on human and wildlife health are considered as inputs to the cumulative effects assessment.

1.7 Risk Assessment Framework

Risk assessment is the primary tool used to characterize the significance of potential health risks to humans and wildlife due to chemical releases from the Project.

The human and wildlife health risk assessment quantifies the potential health risks to people and wildlife from Base Case (present-day) and Application Case (predicted using modelling) environmental quality in the Project area, to determine potential effects resulting from the Project. It is comprised of the following four components:

1) An air quality risk assessment to evaluate the potential acute and chronic effects on human health associated with certain airborne or gaseous substances (i.e., only present in air).

2) A particulate matter risk assessment to evaluate the potential acute and chronic effects associated with inhalation of particulate matter.

3) A multimedia assessment to evaluate potential risks to human health from chemical constituents that might be present in air, soil, water, and food pathways.

4) A multimedia assessment to evaluate potential risks to wildlife health from chemical constituents that might be present in soil, water, and food pathways.

The number of components conducted for the human health risk assessment is dependent upon which environmental media are retained for further evaluation in the risk assessment (i.e., substances that increase as a result of the Project and exceed a health based environmental quality standard or guideline).

The purpose of the wildlife health risk assessment is to assess the potential health risk to wildlife that could result from the Project. The wildlife health risk assessment is conducted by identifying the chemicals or chemical groups present in emissions from the Project, followed by predicting the Project-related changes that may occur in environmental media to which wildlife are exposed (e.g., soil, sediment, water, and food), and then estimating the potential risk that Project-related predicted changes represent to wildlife health. The wildlife health risk assessment is comprised of one component, which is a multimedia food chain assessment to evaluate risk associated with exposure to substances that might be present in soil, sediment, water, and food.

The methods used in this human and wildlife health risk assessment were based on guidance provided by Health Canada (2010a, 2012a), the United States Environmental Protection Agency (US EPA 1989, 1993), the Canadian Council of Ministers of the Environment (CCME 1996/1997) and other applicable risk assessment guidance documents and manuals (e.g., Suter 1993). The overall framework and approach to risk assessment is similar for the human and wildlife health risk assessments, but there are some necessary differences in methods between the two disciplines.

The components of the risk assessment are described further in the following subsections. Figure 1.7-1 and Figure 1.7-2 present the framework for human health and wildlife health risk assessments, respectively. The components of a risk assessment are described below, with a discussion of key considerations that are specific to human or wildlife health.

Figure 1.7-1 Framework for Human Health Risk Assessment

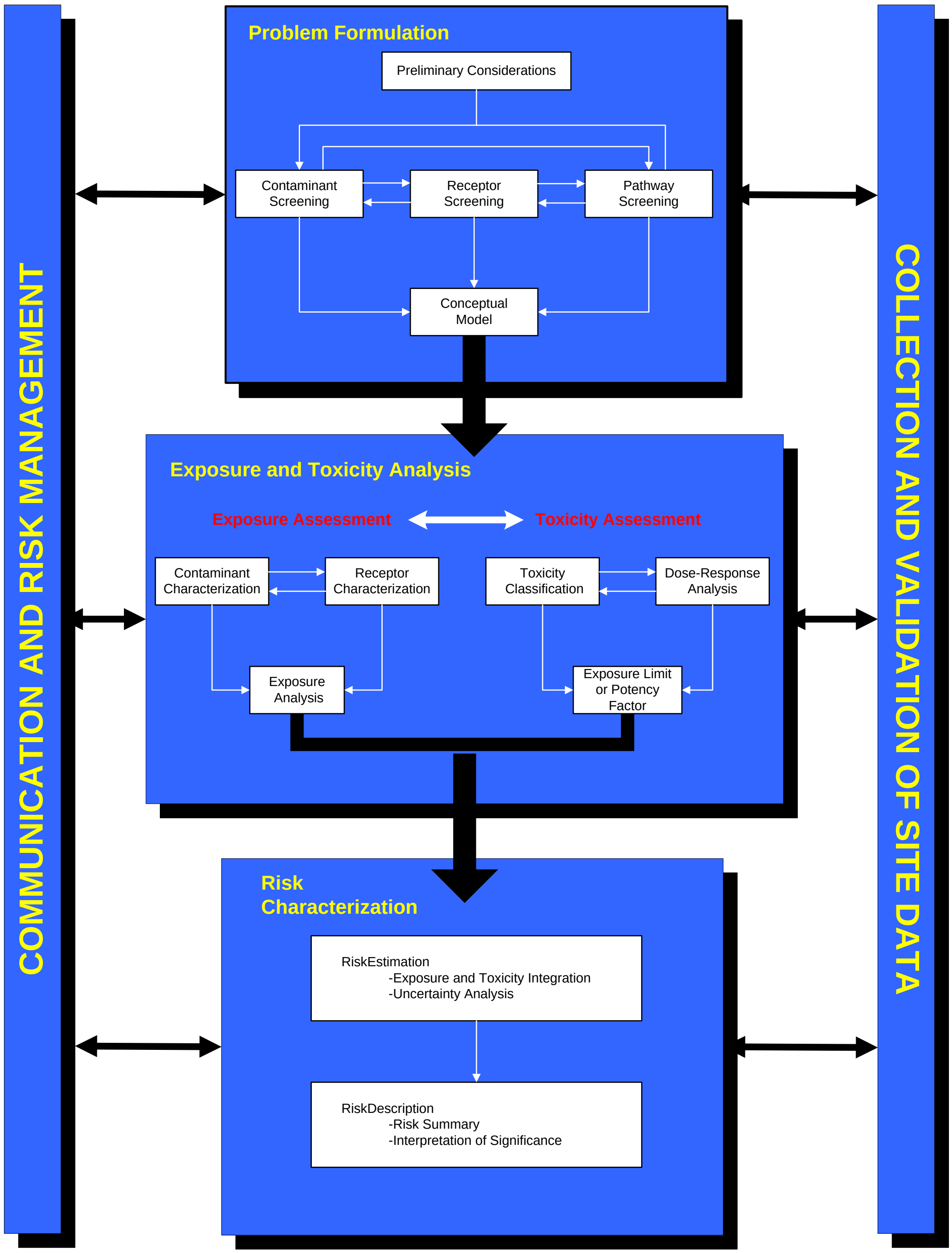
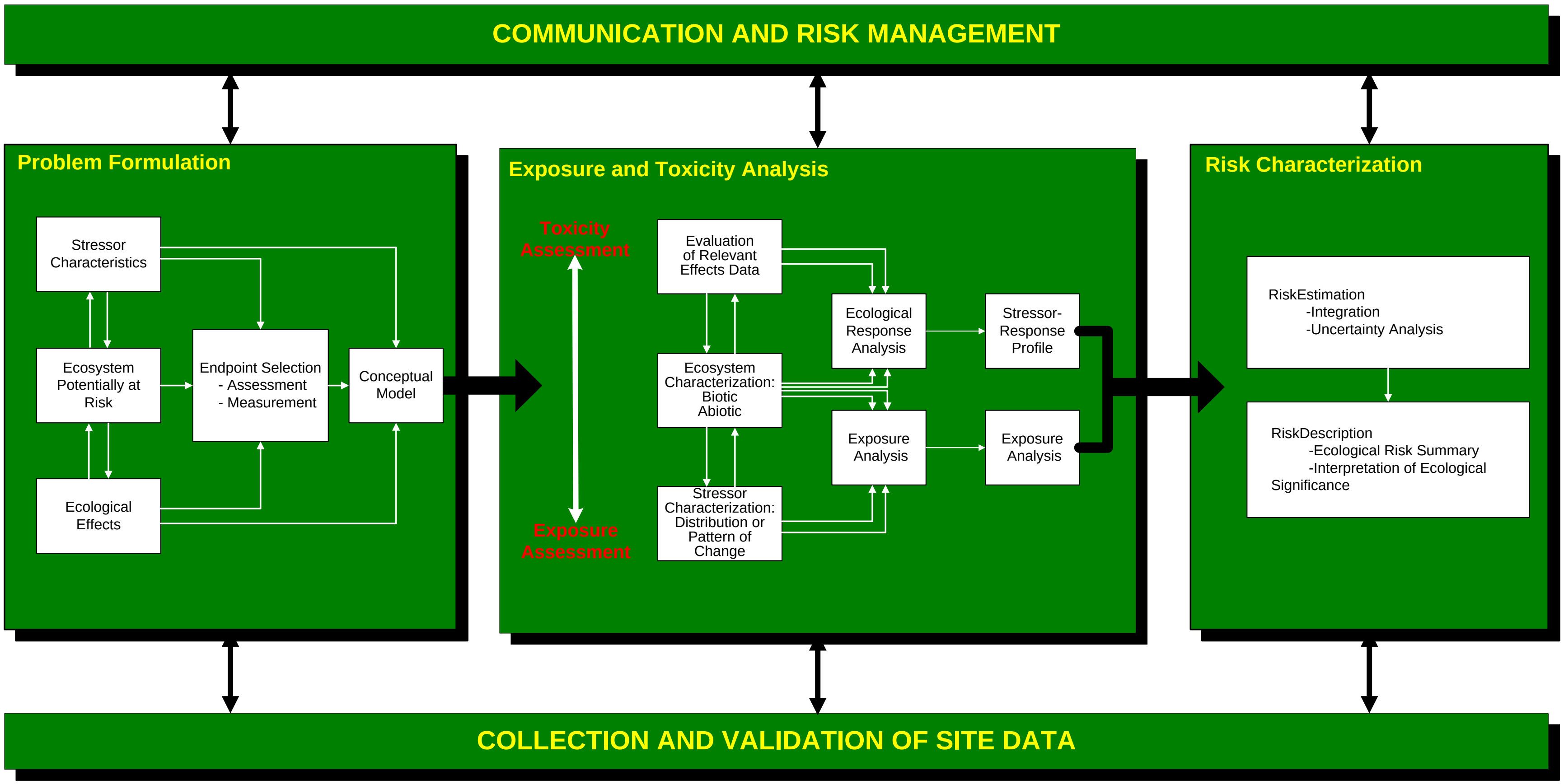


Figure 1.7-2 Framework for Terrestrial Wildlife Health Risk Assessment



1.7.1 Problem Formulation

The problem formulation is focused understanding of how environmental quality might affect the health of people or wildlife near the proposed Project site. The human health and wildlife health risk assessments use similar methods for the problem formulation.

The potential for a human health or wildlife risk to arise from environmental substances is predicated on the co-existence of the following three elements:

- Constituents (e.g., metals) must be present at concentrations that could pose a health effect.
- People or wildlife must be present.
- The potential for people or wildlife to come into contact with the chemicals (called an exposure pathway) must exist.

The objective of the problem formulation was to develop an understanding of how emissions from the Project might affect human and wildlife health. The problem formulation helps to focus the risk assessment on the contaminants, people, wildlife, and exposure pathways of greatest concern, specifically the following:

- constituents of potential concern (COPCs);
- people who are likely to be exposed to COPCs;
- sensitive wildlife species including birds, mammals, and reptiles representing various feeding guilds and habitats (referred to as wildlife receptors); and,
- exposure pathways that account for the majority of exposure to the chemicals emitted.

1.7.2 Exposure Assessment

The exposure assessment involves characterizing the degree to which people or wildlife are exposed to COPCs via the identified exposure pathways.

For people, exposure is calculated for most contaminants as a total daily dose (i.e., amount taken in per day) from the relevant pathways in a multimedia evaluation (e.g., inhalation, ingestion of drinking water and dietary items, direct contact with soil, sediment, and surface water). Exposure to certain airborne or gaseous substances (e.g., nitrogen dioxide) only occurs via the inhalation pathway, and therefore, is expressed as concentrations of these contaminants in air.

For wildlife, exposure is expressed as the total daily dose from diet, drinking water, and incidental or direct ingestion of soil or sediment, determined in a multimedia evaluation.

1.7.3 Toxicity Assessment

The toxicity assessment involves the identification of exposure doses that are considered to be without risk of adverse effects or an acceptably low level of risk of adverse effects as determined by an applicable regulatory agency.

For short-term (acute) human inhalation exposures (assessed in the air quality assessment), toxicity assessment involves identification of health-based regulatory exposure limits or toxicity benchmarks consistent with the exposure averaging time for the evaluation of acute risks.

For people, toxicity assessment involves determination of the rate of intake of a contaminant that can be tolerated over a lifetime without experiencing adverse health effects. Human health risk assessment includes consideration of both carcinogenic and non-carcinogenic effects.

For wildlife, acceptable total daily doses of substances are adopted from relevant guidance documents or, where no recommended value is available, may be derived from published scientific studies.

1.7.4 Risk Characterization

The potential for adverse effects to occur to humans or wildlife is assessed by comparing the estimated exposures (from the respective Exposure Assessments) with those exposures that are determined to be acceptable (from the respective Toxicity Assessments). The characterization of risk includes consideration of uncertainty and conservatism in the risk assessment. The resulting ratio is typically termed a hazard quotient (HQ) and determined according to the following equation:

$$HQ = \frac{Predicted\ Dose\ or\ Concentration}{Estimated\ Safe\ Dose\ or\ Concentration}$$

For human health, the incremental lifetime cancer risk (ILCR) is also estimated for COPCs known to be carcinogenic. Additional detail of how doses and concentrations are compared to toxicological reference values (TRVs) for the air quality and multimedia assessments is provided in Section 4.

General definitions for the potential magnitude of risk associated with HQ and ILCR results are provided in Table 1.7-1. These criteria, which were applied for both human and wildlife health assessments, provide ranges of HQs and ILCRs used to categorize the potential magnitude of risk. The category names of low, moderate, and high are not intended to convey the overall determinations of risk or environmental significance, which can only be made once the uncertainties and conservatism in the analyses have been evaluated.

Table 1.7-1 Criteria Used to Assess Magnitude of Potential Risk for Human and Wildlife Health

Parameter	Levels of Magnitude of Potential Risk			
	Negligible	**Low**	**Moderate**	**High**
Human Health Risk Assessment				
Non-Carcinogenic Substances	No change from Base Case, below applicable guidelines, or HQ≤1	1<HQ≤5	5<HQ≤10	HQ>10
Carcinogenic Substances	No change from Base Case, below applicable guidelines, or ILCR≤1×10^{-5}	1×10^{-5}<ILCR≤5×10^{-5}	5×10^{-5}<ILCR≤1×10^{-4}	ILCR>1×10^{-4}
Wildlife Health Risk Assessment				
All COPCs	No change from Base Case, below applicable guidelines, or HQ≤1	1<HQ≤5	5<HQ≤10	HQ>10

≤ = less than or equal to; < = less than; > = greater than; HQ = hazard quotient (represents the target ratio of the predicted chemical exposure relative to its health-based benchmarks); ILCR = incremental lifetime cancer risk (additional or extra risk of developing cancer due to exposure to a chemical [from the Project] incurred over the lifetime of an individual); COPC = constituent of potential concern.

1.7.5 Consideration of Uncertainty

An inherent uncertainty is associated with risk assessment predictions. The magnitudes of the uncertainties are in large part a function of the quality, quantity, and variability of available data. When information is uncertain, it is standard practice in a risk assessment to make assumptions that are biased towards safety (i.e., conservative assumptions that tend to overestimate exposure and the potential for adverse effects). The conservatism employed in the human and wildlife health risk assessment also builds on the conservatism inherent in the predictions of the air and water quality assessments that serve as primary inputs to the risk assessment. Uncertainty is discussed on a substance-by-substance basis in the assessment of potential residual effects.

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2 EXISTING ENVIRONMENT

Unlike other technical disciplines where field data are used to characterize existing conditions, field data were not used to directly measure existing risks to human and wildlife health. Instead, existing risks must be estimated using the same risk assessment approach and methods used to evaluate how the Project may affect human and wildlife health. As such, there is no baseline report for human and wildlife health. Base Case risk estimates are provided in the Residual Effects Analysis (Section 7.0) to provide context to the predicted risks for the Application Case.

Data used to make predictions about existing and baseline case conditions included a combination of baseline data collected solely to support the HWHRA as well as baseline data and predictions from other disciplines. Baseline data for air quality and deposition, water quality, and fish tissue chemistry were conducted by other disciplines. A terrestrial soil and vegetation baseline field program was conducted specifically to support the HWHRA.

2.1 Terrestrial Soil and Vegetation Baseline Program

A terrestrial baseline field program was conducted in August 2014 to characterize the range of pre-existing environmental constituent concentrations present in soils and terrestrial vegetation.

Sampling and laboratory analysis of co-located soil and vegetation samples was conducted to determine constituent levels in these terrestrial media. The baseline program for soil and vegetation was designed to represent a range of: (1) ecological habitats; (2) distances from existing mining operations and the planned Project footprint; and, (3) locally abundant species that would likely be consumed by humans and wildlife. Sample types included soils, berries, dwarf birch leaves, Labrador tea leaves, willow leaves, grasses, and lichen. The samples collected were analyzed for metals, polycyclic aromatic hydrocarbons, dioxins/furans, and other supporting parameters. Samples of vegetation, were collected with co-located soils to allow for the calculation of bioaccumulation factors from soil.

The baseline program sampling methods, results, and sample locations are provided in Appendix A.

2.2 Information from Other Disciplines

Data from other disciplines used to represent or make predictions about existing conditions include the following:

- Air quality predictions for metals, polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds, particulate matter (PM; consisting of PM_{10}[3] and $PM_{2.5}$[4]), and criteria air contaminants (e.g., nitrogen dioxide and sulphur dioxide), provided by the air quality assessment (DAR Section 7 and Golder 2015a).

[3] PM_{10} is particulate matter with a mean aerodynamic diameter of 10 microns or smaller.
[4] $PM_{2.5}$ is particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller.

- Air deposition rates for metals and PAHs provided by the air quality assessment (presented in Appendix D, Attachment D-1). Derivation of deposition rates are presented in the DAR Section 7. Baseline data collection methods and sampling sites for air quality information and the data used in support of developing the deposition rates are presented in the Air Quality Baseline Report (DAR Annex I).
- Surface water quality baseline data and predictions for metals and conventional parameters, for under ice and open water conditions for Lac de Gras and Lac du Sauvage from the surface water quality assessment as outlined in in the DAR Section 8 and Golder (2015b). Specific data used as input to the health risk assessment are presented in Appendix D.
- Water-to-fish bioaccumulation factors (BAFs) as presented in the DAR Section 8.5.5.3.1

Additional details of baseline data and inputs of predictions from other disciplines into the human and wildlife health risk assessments are provided in Appendix A and Appendix D.

2.3 Base Case Predictions

Predictions of health risks associated with the Base Case are presented for any constituent that screened into the human and terrestrial wildlife health risk assessment (refer to the screening processes described in Section 4). Risk estimates for the Base Case represent the existing environment and provide context for the risk estimates generated for the Construction and Application Cases.

For the air quality and particular matter assessments, the Base Case predictions of air quality and particulate matter predicted by the air quality discipline are applied to represent exposure in the existing environment. These exposure predictions were used to assess risks to people from air inhalation and particulate matter in the existing environment.

For the human health and wildlife health multimedia assessments, the Base Case integrates the information from other disciplines described in Section 2.2, above, along with Base Case estimates of soil, vegetation, and wildlife tissue quality predicted based on the above noted water and deposition information. In addition to predicted changes in soil, vegetation, and country foods, the human and wildlife health multimedia assessments included contribution from exposure to media not expected to change as a result of the Project such as sediment (for wildlife), since these media would also contribute to the overall exposure COPCs.

3 PATHWAY ANALYSIS

3.1 Pathway Analysis – Methods

Pathway analysis identifies and assesses the linkages between Project components or activities, and the corresponding changes to the environment and potential residual effects (after mitigation) on human health and wildlife health. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on human and wildlife health. Potential pathways through which the Project could affect human and wildlife health were identified from several sources including the following:

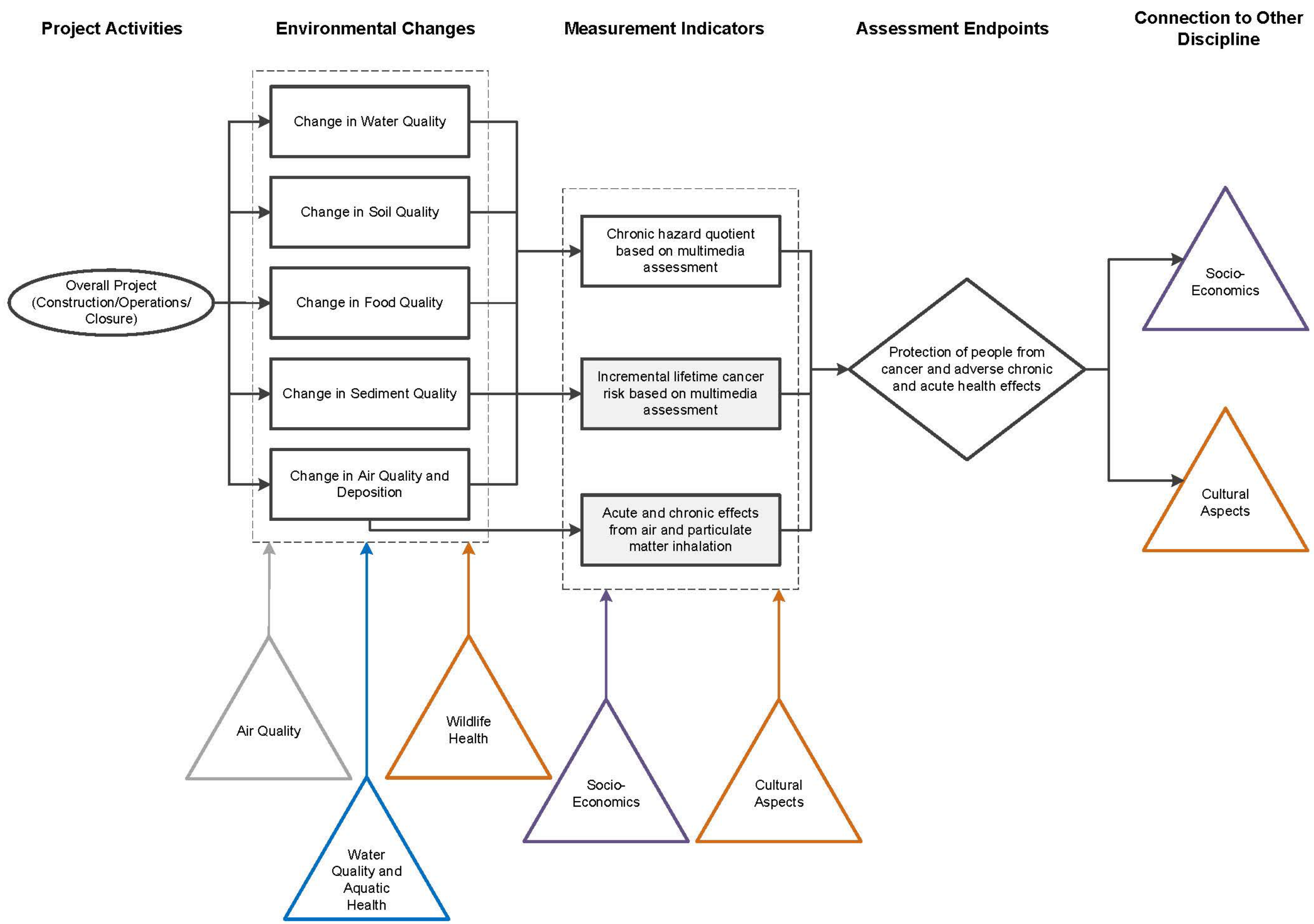
- a review of the Project description and scoping of potential effects by the environmental and engineering teams for the Project;
- information from past and ongoing consultations with Aboriginal communities that are part of the Ekati Mine Community Engagement Programs;
- local and traditional knowledge obtained from community scoping sessions in Behchokǫ̀, Yellowknife, and Łutsel K'e, and a technical scoping session in Yellowknife (refer to the DAR Section 4);
- scientific knowledge and experience with other mines in the NWT;
- review of the pathway analyses presented in the DAR, for air quality, deposition and particulate matter, and for water quality; and,
- consideration of potential effects identified from the TOR (Appendix 1A).

For an effect to occur, there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a corresponding effect on human and/or wildlife health.

Project Activity → **Change in Environment** → **Effect on VC**

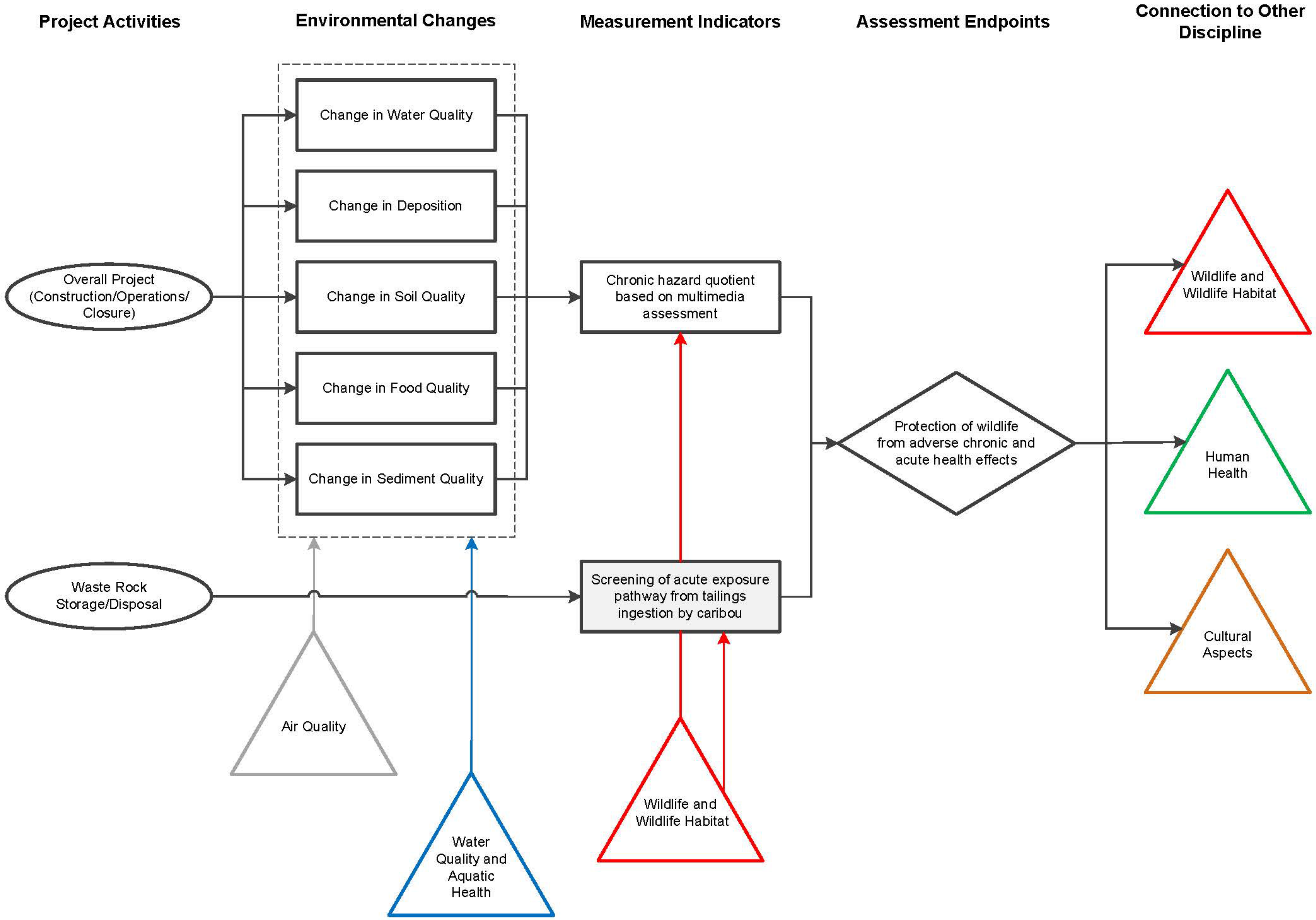
Potential effects from Project activities on valued components before mitigation are presented for human health in Figure 3.1-1 and for wildlife health in Figure 3.1-2. Each pathway or line in the diagrams was initially considered to have a linkage to the human health and wildlife health valued components.

Figure 3.1-1 Linkage Diagram Identifying Potential Effects on Human Health



Note: Ovals represent Project activities; rectangles represent measurement indicators; triangles represent connections to and from other disciplines; and the diamond represents the assessment endpoint.

Figure 3.1-2 Linkage Diagram Identifying Potential Effects on Wildlife Health



Note: Ovals represent Project activities; rectangles represent measurement indicators; triangles represent connections to and from other disciplines; and the diamond represents the assessment endpoint.

A key aspect of the pathway analysis is to identify environmental design features and mitigation that may reduce or eliminate potential effects of the Project to human and wildlife health. Environmental design features include engineering design elements, environmental best practices, management policies and procedures, spill response, and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening-level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on human health and wildlife health. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local and traditional knowledge, logic, and experience with similar developments and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- no linkage – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on human or wildlife health relative to the Base Case or guideline values; or
- secondary – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on human health or wildlife health relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or,
- primary – pathway is likely to result in environmental change that could contribute to residual effects on human or wildlife health relative to the Base Case or guideline values.

Primary pathways require further evaluation through quantitative risk assessment (Problem Formulation in Section 4 and Quantitative Risk Assessment in Section 5). Pathways with no linkage to human or wildlife health are not assessed further because environmental design features or mitigation will remove the pathway. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect human or wildlife health through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment.

3.2 Pathway Analysis – Results

3.2.1 Pathway Screening

Project activities, environmental changes, effect pathways, and environmental design features and mitigation are summarized in Table 3.2-1 for human health and Table 3.2-2 for wildlife health.

For human and wildlife health, the potential Project pathways identified by the other biophysical disciplines (i.e., air quality, water quality) are reviewed to identity whether the potential exists for the Project to affect human or wildlife health through predicted changes to air quality, water quality, or other components of the physical environment. The key pathways for consideration in the human health and wildlife risk assessment are predicted changes to air quality, particulate matter and deposition, and to water quality, as identified in the DAR Sections 7.3 and 8.4, respectively.

Table 3.2-1 Potential Pathways for Effects on Human Health

Project Activities	Environmental Changes	Valued Component	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
Overall Project (Construction/ Operations/Closure)	• Change in water quality • Change in air quality and deposition • Change in soil quality • Change in food quality • Change in sediment quality[(a)]	People	Multimedia exposure to metals and other contaminants	• Environmental design features and mitigation to limit changes in air quality and deposition are presented in DAR Section 7.3 and were incorporated into the exposure predictions for the multimedia assessment. • Environmental design features and mitigation to limit changes in water quality are presented in DAR Section 8.4 and were incorporated into the exposure predictions for the multimedia assessment.	Primary
	Change in air quality Change in particulate matter	People	Inhalation of metals or other contaminants in air. Inhalation of particulate matter in air	• Environmental design features and mitigation to limit changes in air quality particulate matter are presented in DAR Section 7.3 and were incorporated into the exposure predictions the air quality and particulate matter assessments.	Primary

a) Sediment quality is not expected to change as a result of the Project.

DAR = Developer's Assessment Report.

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Table 3.2-2 Potential Pathways for Effects on Wildlife Health

Project Activities	Environmental Changes	Valued Component	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
Overall Project (Construction/ Operations/Closure	• Change in water quality • Change in and deposition • Change in soil quality • Change in food quality • Change in sediment quality[(a)]	Wildlife (including caribou)	Multimedia exposure to metals and other contaminants	• Environmental design features and mitigation to limit changes in air quality and deposition are presented in DAR Section 7.3 and were incorporated into the exposure predictions for the multimedia assessment. • Environmental design features and mitigation to limit changes in water quality are presented in DAR Section 8.4 and were incorporated into the exposure predictions for the multimedia assessment.	Primary
Processed Kimberlite Storage/Disposal	Exposed fine processed kimberlite	Caribou	Caribou may consume fine tailings as a source of salts and minerals.	• Fine processed kimberlite will be deposited to Panda and Koala Pits, which will eventually be flooded at Project closure. Therefore, fine processed kimberlite will not be available for consumption by caribou.	No linkage

a) Sediment quality is not expected to change as a result of the Project.

DAR = Developer's Assessment Report.

These predicted changes to air quality, particulate matter and deposition, and to water quality are applied to assess direct effects on human health from air and particulate matter inhalation, and also incorporated into multimedia models, which predict the effects of changes to soils, vegetation, water, and food on human health and wildlife health. Changes to sediment quality are not predicted to result from the Project, but baseline sediment concentrations are included in exposure predictions for the wildlife multimedia assessment (i.e., exposure to COPCs by wildlife from incidental sediment ingestion remains constant from Base Case to Application Case).

Classification of effects pathways (i.e., primary, secondary, or no linkage) to human health and wildlife health are summarized in Table 3.2-1 and 3.2-2, respectively. For human health, the pathway analysis findings were as follows:

- Multimedia exposure to metals and other contaminants as a result of changes in water quality, air quality and deposition, soil quality and food quality, was considered a primary pathway.
- Inhalation of metals and other contaminants in air as a result of changes to air quality was considered a primary pathway.
- Inhalation of particulate matter as a result of changes to particulate matter in air was considered a primary pathway.

For wildlife health, the pathway analysis findings were as follows:

- Multimedia exposure to metals and other contaminants as a result of changes in water quality, air quality and deposition, soil quality and food quality, was considered a primary pathway.
- Exposure to metals by caribou consuming fine tailings as a source of salts and minerals was considered to have no linkage.

With respect to tailings ingestion by caribou, a study by MacDonald and Gunn (2004) suggests that caribou may be attracted to mine tailings as a source of salt, consuming 20 to 50% of their diet as tailings over short periods of time (i.e., acute exposure). The attraction of caribou to mine tailings is primarily of concern for fine tailings from mining activities where the high surface area and mineral extraction processing can lead to high bioaccessibility and resulting exposure to metals in the event that the fine tailings are consumed. Thus, consumption of fine processed kimberlite is a potential Project effects pathway. However, the Project incorporates a key environmental design feature whereby fine processed kimberlite will be deposited to Koala and Panda Pits, which will then be back-flooded with freshwater at Project closure. This environmental design feature would effectively eliminate the potential for caribou to consume fine processed kimberlite.

3.2.2 Review of Mitigation Effectiveness

As described above, the key pathways for consideration in the human and wildlife health risk assessment are predicted changes to air quality, particulate matter and deposition, and to water quality. Mitigation effectiveness for these changes is discussed in the corresponding section of the DAR (Section 7.3 for air quality, particulate matter and deposition, and Section 8.4 for water quality).

Mitigation of acute exposure by caribou to metals in fine processed kimberlite is discussed in the preceding section.

4 PROBLEM FORMULATION AND APPROACH

The human health risk assessment consisted of the following three components:

1) an air quality risk assessment;
2) a particulate matter risk assessment; and,
3) a multimedia risk assessment.

The air quality risk assessment evaluates exposure to substances that are emitted to air, and addresses human health risks due to short-term or acute exposure, long-term or chronic exposure, and exposure to particulate matter.

The multimedia risk assessment evaluates risks to human health posed by chemical concentrations and/or chemical changes in air, water, soil, sediment, and food, and addresses human health risks due to long-term exposure.

The wildlife health risk assessment is comprised of a multimedia assessment only and evaluated chemical concentrations and/or changes in soil, sediment, water and food pathways, and addresses wildlife health risks due to long-term exposure.

Assessment cases addressed in the human health air quality risk assessment included the Base Case, the Construction Case, and the Application Case as described in Section 1.6. The Construction Case represents prediction of cumulative effects of the developments in the Base Case plus the maximum emission profile for the construction activities associated with the Project. The Application Case was used to evaluate inhalation exposure to air emissions as a result of the operations phase and also to evaluate the predicted cumulative effects of the developments in the Base Case combined with effects from the Project.

Assessment cases addressed in the multimedia risk assessments for human health and wildlife health included the Base Case and the Application Case as described in Section 1.6. The Base Case represents the existing environment based on the cumulative effects of existing developments whereas the Application Case represents the Base Case plus the maximum depositions rates and water quality predictions of the construction and operations phases. The cumulative changes during the construction and operations phases are combined to represent the Application Case for the multimedia risk assessments.

4.1 Human Health – Air Quality Assessment

4.1.1 Problem Formulation

The problem formulation involved determining the receptors, constituents and exposure pathways of greatest concern, as described in Section 1.7.

4.1.1.1 Receptors

Effects on human health were evaluated on a regional basis. The ESA for the human health risk assessment was based on air quality modelling domain, and information about receptor locations identified in consultation with the Traditional Land Use and Socio-Economics disciplines. Specific human receptor locations selected for inclusion in the risk assessment are as follows:

- Courageous Lake Lodge;
- Diavik Camp;
- Diavik Traditional Knowledge (TK) Camp;
- Ekati Camp/Admin;
- Lac de Gras Winter Road Rest Stop;
- Lac de Gras (LDG) Hunting Camp;
- Misery Camp;
- Pellatt Lake Cabin;
- Salmita Airstrip; and,
- Treeline Lodge.

The receptor locations are shown in Map 1.5-2. Specific human activities at the receptor locations are described in Section 4.4.1.1.

In addition to the locations listed above, the short-term air quality assessment also considered people that may spend short amounts of time at a hypothetical “worst-case” location outside the mine site area (maximum point of impingement [MPOI]). The hypothetical “worst case” location did not overlap with any of the receptor locations identified above, and therefore, use or access by the people is considered to be on an infrequent basis.

There are three work camps and these were considered in the air quality assessment – they include the Diavik Camp, the Ekati Main Camp, and Misery Camp. Health and safety is covered under company and occupational health and safety plans and through monitoring that is conducted as needed. However, to inform health and safety planning, and because people other than workers may visit the work camps, in addition to workers, contractors working for the Project or people visiting the work camps were included as receptors in the air quality assessment.

The air quality assessment evaluated potential risks to people of various ages (infants, toddlers, children, teens and adults) who may visit the locations identified above and may in future be exposed to COPCs resulting from the construction and operation of the Project.

4.1.1.2 Constituents Considered in the Air Quality Assessment

People may be exposed to constituents emitted by the Project via direct inhalation of airborne chemicals.

COPCs were identified by developing an inventory of constituents that could be emitted or released by the Project, to which people may be exposed. The Air Quality discipline conducted an air emissions inventory of chemicals, which formed the initial list of constituents used in the identification of COPCs for the air quality risk assessment. The air emission inventory grouped constituents into the following groups: acid gases (e.g., sulphur dioxide, nitrogen dioxide), particulate matter, volatile organic compounds (VOCs), metals, and polycyclic aromatic hydrocarbons (PAHs).

Constituent Groups and Surrogates

Constituents that had sufficient toxicity information to be assessed on an individual basis were evaluated discretely (e.g., benzene, toluene). However, several constituents were evaluated within a constituent group, rather than as individual constituents for the following reasons:

- Toxicity information was limited for these constituents.
- Compounds with similar structures may act additively.
- Some toxicity information was available for chemical mixtures.

When constituents were assessed as a group, surrogate constituents were used to represent the group. The surrogate approach relies on the toxicological principle that the molecular structure of a constituent has a distinct bearing on its reactivity, biological activity, and toxicity. The surrogate approach allows for the toxicity of a constituent or a group of constituents for which little or no toxicological information exists to be predicted based on information available on another constituent of similar molecular structure, especially when the structure is associated with a similar toxicological mode of action. Therefore, surrogates were selected that were structurally similar and typically represented one of the more toxic and volatile compounds in the mixture for which good supporting toxicity information was available. The surrogate approach relies on the fact that the majority of the constituents in the mixture are less toxic and volatile than the surrogate. Therefore, using a surrogate that represents one of the more toxic and volatile compounds present in the mixture will overestimate risk as the surrogate will typically only account for a small percentage of the total mixture. The constituent groupings are discussed in the sections below.

Volatile Organic Compounds

VOCs consist of a variety of organic compounds that tend to rapidly volatilize to air following emission. The majority of the VOCs emitted by the Project were assessed individually, while aliphatic and aromatic hydrocarbons were evaluated using the surrogate approach. The constituents included in each of the groups evaluated by the surrogate approach are listed in Table 4.1-1. As well, the VOCs assessed individually are provided in Table 4.1-2. The surrogates used for constituent groups are identified in Appendix B (Tables B-1, B-2 and B-3).

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Polycyclic Aromatic Hydrocarbons

For the human health air quality assessment, PAHs were assessed individually. For some carcinogenic PAHs, chronic screening criteria were not available. In these cases, toxic equivalency factors (based on toxic equivalency relative to benzo(a)pyrene) were applied. The toxic equivalency factors for the PAHs were obtained from Health Canada (2010b). For non-carcinogenic PAHs, screening criteria were not available in some cases. In these cases, screening criteria were adopted from PAHs with similar structure and toxicity (see Appendix B).

Metals

Metals were assessed individually.

Particulate Matter

For the human health air quality assessment, particulate matter fractions $PM_{2.5}$ and PM_{10} were assessed individually for both acute and chronic exposure. Short-term exposure to $PM_{2.5}$ and PM_{10} was assessed under the 24 hour exposure scenario (1 hour screening criteria were not available) and as part of the acute effects literature review. The particulate matter assessment is presented separately from the rest of the air quality assessment (Sections 4.1.3 [Methods], 5.1.3 [Residual Effects], and Appendix G [Qualitative Literature Assessment]).

Table 4.1-1 Constituent Groupings Assessed in the Air Quality Risk Assessment

Constituent Group	Constituents Within the Group
Volatile Organic Compounds	
C_2-C_6 Aliphatic	1,3-Butadiene, butane, cis-2-butene, trans-2-butene, cyclohexane, cyclopentane, 2,2-dimethylbutane, 2,3-dimethylbutane, ethylene, cis-2-hexene, trans-2-hexene, isobutene, isopentane, 2-methyl-1-butene, 3-methyl-1-butene, 2-methyl-2-pentene, methylcyclopentane, 2-methylpentane, 3-methylpentane, pentane, trans-2-pentene
>C_6-C_8 Aliphatic	2,3-dimethylhexane, 2,4-dimethylhexane, 2,5-dimethylhexane, 2,3-dimethylpentane, 2,4-dimethylpentane, 3-ethylhexane, heptane, methylcyclohexane, 2-methylheptane, 2-methylhexane, 3-methylhexane, 2,2,4-trimethylpentane, 2,3,4-trimethylpentane, octane
>C_8-C_{10} Aliphatic	Nonane
>C_{10}-C_{12} Aliphatic	Dodecane, pentylcyclohexane
>C_{12}-C_{16} Aliphatic	Farnesane, hexadecane, n-pentadecane, tetradecane, tridecane
>C_{16}-C_{21} Aliphatic	Dodecylcyclohexane, n-eicosane, n-heneicosane, n-heptadecane, n-octadecane, n-nonadecane, pentadecylcyclohexane, pristine, tetradecylcyclohexane, tridecylcyclohexane
C_6-C_8 Aromatic	Benzene, ethylbenzene, toluene
>C_8-C_{10} Aromatic	3-Ethyl-toluene (m-ethyltoluene), 4-ethyl-toluene (p-ethyltoluene), propylbenzene
Xylenes	o-xylene, xylenes

> = greater than.

Table 4.1-2 Individual Constituents Assessed in the Air Quality Risk Assessment

Constituent Group	Constituents Within the Group
Critical Air Contaminants	Carbon monoxide, nitrogen dioxide, sulphur dioxide, total suspended particulates, $PM_{2.5}$ and PM_{10}
Metals	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium[a], cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, tellurium, thallium, titanium, tungsten, uranium, vanadium, zinc
Volatile Organic Compounds	Acetaldehyde, acrolein, benzaldehyde, butanal (butyraldehyde), crotonaldehyde, decanal, 2,5-dimethylbenzaldehyde, dodecanal, formaldehyde, heptanal, hexanal, methacrolein, nonanal, octanal, propanal, tridecanal, undecanal 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene Acetone, acetophenone, indanone, methyl ethyl ketone 1,1,1-trichloroethane
Polycyclic Aromatic Hydrocarbons	acenaphthene, acenaphthylene, acephenanthrylene, anthracene, benz(a)anthracene, benzo(a)fluorene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(e)pyrene, benzo(g,h,i)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, biphenyl, chrysene, coronene, cyclopenta(cd)pyrene, dibenzo(a,h)anthracene, dibenzothiophene, fluoranthene, fluorene, indeno(1,2,3-cd)fluoranthene, indeno(1,2,3-cd)pyrene, indeno(1,2,3-W)pyrene, 2-methylanthracene, 3-methyldibenzothiophene, 4-methyldibenzothiophene, 2-methylflourene, 1-methylnaphthalene, 2-methylnaphthalene, 1-methylphenanthrene, 2-methylphenanthrene, 3-methylphenanthrene, 4-+9-methylphenanthrene, 9-methylphenanthrene, 2-methylpyrene, naphthalene, nitropyrene, perylene, phenanthrene, picene, pyrene

a) As chromium speciation information was not available (i.e., relative proportions of hexavalent and trivalent forms were not determined), only predictions for total chromium were available. For the purposes of evaluating toxicity to human receptors, total chromium was assumed to be entirely chromium (VI) because the toxicity associated with the hexavalent form is typically greater than the trivalent form.

$PM_{2.5}$ = particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller; PM_{10} = particulate matter with a mean aerodynamic diameter of 10 microns or smaller.

4.1.1.3 Exposure Pathways

The acute and chronic inhalation exposure pathways were evaluated for the air quality risk assessment.

4.1.2 Short-Term (Acute) and Long-Term (Chronic) Human Health Inhalation Risk Assessment Methods

This section includes the methods used to evaluate what effects emissions from existing and approved developments and the Project could have on short-term (acute) and long-term (chronic) exposure and human health. Methods for the assessment of particulate matter are in Section 4.1.3.

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4.1.2.1 COPC Screening

For each constituent, 1-hour, 24-hour, and annual concentrations were predicted for the receptor locations identified above in Section 1.5. Predicted concentrations were compared to the most conservative (i.e., lowest) of available 1-hour, 24-hour, and chronic health-based thresholds, preferentially obtained from the following agencies:

- Northwest Territories Ambient Air Quality Guidelines;
- World Health Organization;
- Agency of Toxic Substances and Disease Registry (ATSDR); and,
- Canadian Council of Ministers of the Environment (CCME).
- United States Environmental Protection Agency (US EPA) Regional Residential Air Screening Levels for Chemical Contaminants at Superfund Sites (chronic inhalation assessment only).

The lowest health-based threshold with supporting information was generally selected for use in the screening process. Consideration was also given to relevant species (i.e., human data versus animal data), study endpoint, quality and date of the study.

Where a health-based screening threshold was not available from the agencies listed above, the lowest available health-based thresholds from the following agencies were used:

- Ontario Ministry of the Environment (OMOE);
- California Environmental Protection Agency Office of Environmental Health Hazard Assessment; and,
- Texas Commission on Environmental Quality.

Priority was given to health-based screening levels that had supporting documentation.

The available 1-hour, 24-hour, and chronic health-based thresholds and the basis of these thresholds are presented in Appendix B. For chronic thresholds, risk levels for which the screening levels/guidelines were derived were standardized to risk levels considered acceptable by the World Health Organization and Health Canada (WHO 2010; Health Canada 2010a). For non-carcinogens, this involved adjusting to a hazard quotient of 1.0, and for carcinogens, this involved adjusting to a risk level of 1×10^{-5} (i.e., one in 100,000). Further information on the approach used to develop the screening levels/guidelines/objectives for each of the agencies is provided in Appendix B.

Predicted maximum Construction Case and Application Case 1-hour, 24-hour, and annual ground level air concentrations were compared to the selected 1-hour, 24-hour, and chronic thresholds (Appendix B).

A parameter was retained for further evaluation if the predicted maximum Construction Case or Application Case concentration (i.e., maximum concentration during construction, and maximum concentration during Project operations, respectively, at any of the selected receptor locations) was greater than the selected screening level and increased by more than 10% above predicted Base Case concentrations. A parameter that was retained for further assessment was classified as a COPC and was evaluated at each selected receptor location.

Based on the screening results presented in Appendix E, the COPCs retained for the short- and long-term air inhalation risk assessment are presented in Table 4.1-3.

Table 4.1-3 Constituents of Potential Concern Identified in the Short- and Long-term Inhalation Assessment and Location

COPC	Construction Case	Application Case (Operations)
1-Hour		
Aluminum	√ (Misery Camp, MPOI)	√ (MPOI)
Barium	-	√ (MPOI)
Beryllium	-	√ (MPOI)
Cadmium	-	√ (MPOI)
Chromium (as Cr(VI))	√ (MPOI)	√ (MPOI)
Iron	√ (MPOI)	√ (MPOI)
Manganese	-	√ (MPOI)
Nickel	-	√ (MPOI)
24-Hour		
Nitrogen Dioxide	-	√ (MPOI)
Aluminum	√ (MPOI)	√ (MPOI)
Cadmium	-	√ (MPOI)
Chromium, as Cr(III) or total Cr	-	√ (MPOI)
Chromium, as Cr(VI)	√ (MPOI)	√ (MPOI)
Iron	√ (MPOI)	√ (MPOI)
Manganese	√ (MPOI)	√ (MPOI)
Nickel	-	√ (MPOI)
Annual		
Chromium, as Cr(VI) and as a carcinogen	√ (Diavik TK Camp, LDG Hunting Camp)	√ (Diavik TK Camp, LDG Hunting Camp, Misery Camp)

COPC = constituent of potential concern; MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge; √ = constituent of potential concern (concentrations exceed a screening threshold ; “-“ – no exceedances of screening thresholds.

4.1.2.2 Short Term (Acute) Inhalation Assessment

4.1.2.2.1 Toxicity Assessment

Toxicity assessment involves the classification of the toxic effects of chemicals and the estimation of the amounts of chemicals that can be received by an organism without adverse health effects. For short-term (acute) human inhalation exposures (assessed in the air quality assessment), toxicity assessment involves identification of health-based regulatory exposure limits or toxicity benchmarks consistent with the exposure averaging time for the evaluation of acute risks.

The short-term inhalation thresholds used in the risk characterization were selected as outlined in Section 4.1.2.1 above.

The toxicological basis of the selected thresholds is presented in Appendix E.

4.1.2.2.2 Exposure Assessment

The exposure assessment is the process of estimating the exposure of a person to a substance under a given exposure scenario. Short-term exposures were assessed for 1-hour and 24-hour averaging times, for the receptor locations identified in Section 4.1.1.1, and included both recreational locations and work camps. Maximum predicted 1-hour and 24-hour ground level air concentrations during construction and operations (Construction Case and Application Case, respectively) were compared to acute threshold concentrations, as described in the section below on risk characterization.

4.1.2.2.3 Risk Characterization

For each of the 1-hour and 24-hour COPCs, for each receptor and for the Base Case, Construction Case, and Application Case, a hazard quotient (HQ) was calculated as follows:

$$HQ = \frac{\text{COPC Concentration in air } (\mu g/m^3)}{\text{Acute Threshold Concentration } (\mu g/m^3)}$$

An HQ greater than 1.0 indicates that exposure is greater than the screening threshold. For COPCs and locations where HQ values were greater than 1.0 for the Construction Case or Application Case, additional analysis was done to determine the magnitude of the effect. The following approach was used on a case-by-case basis to determine the magnitude of risk (i.e., negligible, low, moderate, or high):

- comparison of the maximum, 95th and 75th percentile air concentrations to acute exposure limits to provide additional context to predicted risk;
- comparison of Construction or Application Case concentrations to Base Case concentrations;
- comparison of the number of exceedances predicted to occur in a year for the Construction Case, Application Case, and Base Case;
- evaluation of the conservatism in the air modelling approach used to predict future concentrations;

- evaluation of the conservatism in the acute exposure limits for that parameter; and,
- evaluation of the potential acute health effects that may occur at the predicted concentrations.

The above information was used to determine the magnitude of potential risks to health resulting from short-term air exposures at receptor locations. The results are provided in Section 5.1.

4.1.2.2.4 Toxicity of Mixtures

Toxicity of chemical mixtures was addressed by summing hazard quotients (HQs) for COPCs that contribute to the same type of toxic effect.

For COPCs with HQs greater than 1.0, the HQs for which thresholds were based on similar target organs were added together to determine a total HQ for similar toxicological effects. The COPCs for which HQs were summed by target organ endpoints are shown in Table 4.1-4. Further information on the target organ(s) and effect(s) of each COPC are provided in Appendix B (air screening).

Table 4.1-4 Potential Additive Interactions of the Constituents of Potential Concern for the Human Health Short Term (24-hour) Air Quality Inhalation Assessment

Constituent of Potential Concern	Pathway	Target Organ	Effects	Threshold Source
Cadmium	Inhalation	Respiratory tract	Histological alterations	ATSDR 2012a
Chromium (VI)	Inhalation	Respiratory tract	Increased lung weight	TCEQ 2014
Nickel	Inhalation	Respiratory tract	Lung fibrosis	OMOE 2011

4.1.2.3 Long-Term (Chronic) Inhalation Assessment

Chromium was the only COPC identified for the chronic inhalation assessment.

4.1.2.3.1 Toxicity Assessment

Toxicity assessment involves the classification of the toxic effects of chemicals and the estimation of the amounts of chemicals that can be received by an organism without adverse health effects. An appropriate toxicity reference value (TRV) was determined based on reported mode of action (i.e., threshold vs. non-threshold mode of action). For threshold chemicals (i.e., generally not a carcinogen), adverse effects are expected to only occur above a certain dose rate. However, for non-threshold chemicals (i.e., most carcinogens) theoretically any dose can potentially lead to adverse effects.

Contaminant Classification

Different agencies and jurisdictions will classify contaminants based on their mode of action (i.e., threshold vs. non-threshold substances). Chemical classification is described in Appendix E (toxicity assessment). The chemical classification for chromium, based on US EPA, Health Canada, and the International Agency for Research on Carcinogens is summarized in Table 4.1-5.

Table 4.1-5 Carcinogenicity Classification of Chromium

Constituent of Potential Concern	Health Canada[(a)]	US EPA[(b)]	IARC[(c)]	Assessed as a Carcinogen?
Metals				
Chromium	NC[(d)]	Group D[(e)]	Group 3[(e)]	Yes
Chromium (VI)	Group I[(f)]	Group D[(g)] Group A[(f)]	Group 1	

Note:
Group 1 = carcinogenic to humans
Group I = carcinogenic to humans
Group A = human carcinogen
Group D = unclassifiable as to human carcinogenicity
Group 3 = unclassifiable as to human carcinogenicity
NC = not classified
IARC = International Agency for Research on Cancer;
US EPA = United States Environmental Protection Agency.

a) Health Canada (2010b).
b) US EPA (2014a).
c) IARC (2014).
d) Total chromium.
e) Chromium (III).
f) Via inhalation pathway.
g) Via oral pathway.

Although chromium can exist in the valences states –2 to +6, the trivalent (+3) and the hexavalent (+6) states are the two most common species. Chromium (III) is generally considered the most thermodynamically stable of the two species under ambient redox conditions (CCME 1999). Chromium III is the most common and naturally occurring state of chromium and is an essential element for humans. Toxic effects of chromium are attributed primarily to the hexavalent form. Chromium (VI) rarely occurs naturally in the environment and is most commonly the result of industrial and domestic emissions.

As speciation information was not available (i.e., relative proportions of hexavalent and trivalent forms were not determined), only predictions for total chromium were available. For the purposes of evaluating toxicity to human receptors, total chromium was assumed to be entirely chromium (VI) because the toxicity associated with the hexavalent form is typically greater than the trivalent form.

Toxicity Reference Values

Toxicity Reference Values were obtained preferentially from Health Canada (2010b) and from the US EPA's Integrated Risk Information System (US EPA 2014a). Selection of the final TRV was based on the currency of the study, study duration (i.e., chronic duration preferred), and whether the critical endpoint was based a no-observed-adverse-effect level (NOAEL). When a suitable TRV was not available from Health Canada (2010b) or US EPA's Integrated Risk Information System, the following sources were also consulted:

- World Health Organization (WHO 2014);
- Netherlands National Institute of Public Health and the Environment (RIVM 2001, 2009);
- Agency of Toxic Substances and Disease Registry (ATSDR) minimal risk levels (ATSDR 2013);
- California Environmental Protection Agency (Cal EPA OEHHA 2007); and,
- US EPA provisional peer-reviewed toxicity reference values (US EPA 2014b).

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Chromium was the only COPC retained for the long-term inhalation assessment and was assessed as a carcinogen. An inhalation TRV for a carcinogenic chemical is called an inhalation unit risk (IUR). An IUR is the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to a constituent at a concentration of 1 µg/m^3 in air.

The available IURs, selected IUR and the toxicological basis of the IURs are presented in Appendix E.

4.1.2.3.2 Exposure Assessment

The exposure assessment is the process of estimating the exposure of a person to a substance under a given exposure scenario. Chronic exposures estimates were based on the predicted annual average air concentrations for chromium (evaluated as a carcinogen).

For the work camps, an exposure amortization factor of 10 hours/24 hours was applied to the predicted annual average air concentration to account for the amount of time workers are likely to be outside or be exposed to outdoor air. It was assumed that workers were adults and could be exposed daily for their adult lifetime (i.e., 60 years of a lifetime of 80 years).

For the remaining locations (i.e., hunting camp, accommodation, lodges), it was assumed that recreational receptors may access the ESA for hunting and/or fishing for three months of the year (presumably the hunting season in later summer-fall). Although many visiting hunters and fishers or community members are only in the area for a short period of time (e.g., 1 to 2 weeks), it was assumed that a guide could remain at the camp and engage in hunting and fishing activities throughout the season, for a period of up to 3 months. Therefore, an exposure amortization factor of 14 hours/24 hours and 3 months/12 months (or approximately 91 days/365 days) was applied to the predicted annual average air concentration to account for the amount of time people may be spending outdoors while carrying out recreational activities. The chromium cancer assessment (i.e., estimation of ILCRs) for recreational users was conducted for a composite receptor. The composite receptor approach was used to assess risk across all life stages combined over a lifetime.

4.1.2.3.3 Risk Characterization

Chromium was the only COPC identified for the chronic inhalation assessment, and was assessed as a carcinogen. Risk estimates generated for carcinogens are based on the ILCR, which is the additional cancer cases attributed to the incremental exposures to arsenic as the result of the Project. Interpretation of these ILCRs was based on comparison of the calculated ILCR values with the “benchmark” of 1 in 100,000 (i.e., one extra cancer case in a population of 100,000 people). Health Canada (Health Canada 2010a) considers cancer risks from chemical exposure to be essentially negligible if the ILCR is less than 1 in 100,000 (1 x 10^{-5}). For carcinogenic COPCs, ILCRs were calculated as the product of the predicted COPC concentration in air amortized for exposure to outdoor air and the IUR, according to the following equation:

$$\text{ILCR} = \text{concentration in air } \left(\mu g / m^3\right) \times hours / hours \times days / days \times \text{IUR } \left(\mu g / m^3\right)^{-1}$$

For chromium, at locations where ILCR values were greater than 1.0 x 10^{-5} for the Construction and Application Cases, the following approach was used to determine the magnitude of risk (i.e., negligible, low, moderate, or high):

- comparison of the maximum annual air concentrations to the toxicity reference value (unit risk) for arsenic to provide additional context to predicted risk;
- comparison of Construction and Application Case concentrations to Base Case concentrations;
- evaluation of the conservatism in the air modelling approach used to predict future concentrations;
- evaluation of the conservatism in the unit risk for arsenic; and,
- Evaluation of the potential chronic health effects that may occur at the predicted concentrations.

The above information was used to determine the magnitude of potential effects on health resulting from chronic air exposures at the selected receptor locations.

4.1.3 Particulate Matter

4.1.3.1 Particulate Matter Assessment Methods

This section includes the methods used to evaluate what effects emissions from existing and approved developments and the Project could have on short-term (acute) and long-term (chronic) exposure and human health from particulate matter.

4.1.3.1.1 COPC Screening

For both PM_{10} and $PM_{2.5}$, 24-hour and annual concentrations were predicted for the receptor locations identified above in Section 4.1.1.1. One-hour concentrations were not predicted as screening thresholds are not available and short-term inhalation exposure was evaluated under the 24-hour exposure scenario. Predicted concentrations were compared to the most conservative (i.e., lowest) of available 24-hour and chronic health-based thresholds, preferentially obtained from the following agencies:

- Northwest Territories Ambient Air Quality Guidelines;
- World Health Organization;
- Agency of Toxic Substances and Disease Registry (ATSDR); and,
- Canadian Council of Ministers of the Environment (CCME).
- United States Environmental Protection Agency (US EPA) Regional Residential Air Screening Levels for Chemical Contaminants at Superfund Sites (chronic inhalation assessment only).

The lowest health-based threshold with supporting information was generally selected for use in the screening process. Consideration was also given to relevant species (i.e., human data versus animal data), study endpoint, quality and date of the study. Priority was given to health-based screening levels that had supporting documentation.

The available 24-hour and chronic health-based thresholds and the basis of these thresholds are presented in Appendix E.

Predicted maximum Construction Case and Application Case 24-hour and annual ground level air concentrations were compared to the selected 24-hour and chronic thresholds, respectively (Appendix B).

A parameter was retained for further evaluation if the predicted maximum Construction Case or Application Case concentration (i.e., maximum concentration during construction, and maximum concentration during Project operations, respectively, at any of the selected receptor locations) was greater than the selected screening level and increased by more than 10% above predicted Base Case concentrations. A parameter that was retained for further assessment was classified as a COPC and was evaluated at each selected receptor location.

Based on the screening results presented in Appendix E, the COPCs retained for the particulate matter assessment are presented below in Table 4.1-6.

Table 4.1-6 Particulate Matter COPCs Retained for Further Assessment

COPC	Construction Case	Application Case (Operations)
24-Hour		
PM_{10}	√ (Diavik Camp, Misery Camp, MPOI)	√ (Diavik Camp, MPOI)
$PM_{2.5}$	√ (Diavik Camp, Misery Camp, MPOI)	√ (Diavik Camp, Misery Camp, MPOI)
Annual		
None retained	NA	NA

COPC = constituent of potential concern; MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); √ = constituent of potential concern ; NA = not applicable; $PM_{2.5}$ = particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller; PM_{10} = particulate matter with a mean aerodynamic diameter of 10 microns or smaller.

4.1.3.2 Short Term (Acute) Particulate Matter Assessment

4.1.3.2.1 Toxicity Assessment

Toxicity assessment involves the classification of the toxic effects of chemicals and the estimation of the amounts of chemicals that can be received by an organism without adverse health effects. For short-term (acute) human inhalation exposures (assessed in the air quality assessment), toxicity assessment involves identification of health-based regulatory exposure limits or toxicity benchmarks consistent with the exposure averaging time for the evaluation of acute risks.

The short-term inhalation thresholds used in the risk characterization were selected as outlined in Section 4.1.4.1 above.

The toxicological basis of the selected thresholds is presented in Appendix E.

4.1.3.2.2 Exposure Assessment and Risk Characterization

There is no prescribed method for assessing health risks of particulate matter, nor does the assessment of particulate matter lend itself to risk assessment methods in the same manner as other parameters. For many years, particulate matter in the air has been understood to be a serious health concern (Shwarze et al. 2006). Many epidemiological studies have been conducted that identify the relationship between particulate matter and adverse health outcomes (WHO 2006). The studies have shown that there is a broad range of health effects, but predominantly there is a relationship between particulate matter and mortality and hospitalizations for respiratory and cardiac health effects (WHO 2006). However, there remains uncertainty regarding the causal linkage between particulate matter and health effects and in particular how varying compositions of particulate matter contribute to health effects (Shwarze et al. 2006; Rohr 2012). An increasing number of health effects have been linked to airborne particulate matter and research has shown that there are risks to health at levels already found in many cities across the world (WHO 2006). Current research generally suggests that the composition of particulate matter would be a better predictor of adverse health effects than the mass of particulate matter (Stanek et. al. 2011). In addition, particulate matter is considered to be a stressor that can cause negative health outcomes at any exposure level and therefore lacks a threshold that can act as a guideline (WHO 2010). Therefore, for particulate matter, the guideline values are concentrations that correspond to a tolerable level of risk and are not fully protective of public health (WHO 2010).

Particulate matter is comprised of a mixture of different chemicals and biological components and as such, differs from individual chemicals (WHO 2010). There is no prescribed method for assessing health risks of particulate matter, nor does the assessment of particulate matter lend itself to risk assessment methods in the same manner as other parameters. The effects on human health as a result of exposure to particulate matter due to emissions from existing and approved developments and the Project were evaluated qualitatively for $PM_{2.5}$ and PM_{10}.

The following approach was used as part of the qualitative assessment:

- comparison of the maximum, 95^{th}, and 75^{th} percentile air concentrations to acute exposure limits to provide additional context to predicted risk;
- comparison of Construction or Application Case concentrations to Base Case concentrations;
- comparison of the number of exceedances predicted to occur in a year for the Construction Case, Application Case, and Base Case;
- evaluation of the conservatism in the air modelling approach used to predict future concentrations;
- evaluation of the conservatism in the acute exposure limits for that parameter;
- evaluation of the potential acute health effects that may occur at the predicted concentrations; and,
- a review of relevant literature which discusses the acute effects of particulate matter on human health.

The results of the particulate matter assessment are provided in Section 5.1.3 and the literature review is presented in Appendix G.

4.1.3.3 Long-Term (Chronic) Particulate Matter Assessment

No COPCs were identified for the long-term particulate matter assessment.

4.2 Human Health – Multimedia Assessment

4.2.1 Problem Formulation

4.2.1.1 Receptors

Map 1.5-2 illustrates the locations used by people within the ESA. There are no communities located within the ESA, and the major human activities are described below:

- **Workers camps:** These include the Ekati Mine, Diavik Mine, and Misery operations camps. Workers are present on a two week on, two week off rotation.
- **Aboriginal seasonal hunting activities:** The ESA has been traditionally and continues to be used for harvesting of country foods (e.g., caribou, fish, berries, plants) by local Aboriginals. Although no formal camps exist, the area between Lac de Gras and Lac du Sauvage (i.e., the Narrows) has been a traditionally important caribou hunting location, as noted in the traditional land use report (DAR Section 15). The Pellatt Lake cabin is owned by an Aboriginal family, and had been used seasonally in the past, but has not been used in the last several years.
- **Lodges and accommodations:** Hunting lodges include the Courageous Lake lodge and the Lac de Gras hunting camp. Treeline lodge has been used as an accommodation for exploration companies, as well as visiting hunters, fishers, and tourists. Although most visitors to these lodges are only present for a short duration (e.g., 1 to 2 weeks), hunting guides may be present for the duration of the hunting season. The Salmita airstrip is associated with the Treeline lodge. The Lac de Gras winter road rest stop is a road maintenance and driver rest stop for the Tibbitt to Contwoyto winter road, and is only used during the winter. Most of the hunting lodges have not been used commercially since the moratorium on caribou hunting, but it was assumed that local Aboriginals may use some of these camps (e.g., the Lac de Gras hunting camp) or the winter road rest stop as a staging area for hunting trips.
- **Community camps:** The Diavik TK Camp has been used as a meeting spot to discuss issues pertaining to water quality and fish health by Diavik support staff and community members (youths and elders). To date, meetings have taken place for one week every three years.

Based on the human activities that take place, the following receptors were considered for the human health multimedia assessment:

Aboriginal Seasonal Users: Includes local Aboriginals of all ages that may access the ESA for collection of country foods (hunting, fishing, or gathering), and/or attending community meetings at the Diavik TK camp. Aboriginal seasonal users also include the family that may access the Pellatt Lake cabin seasonally.

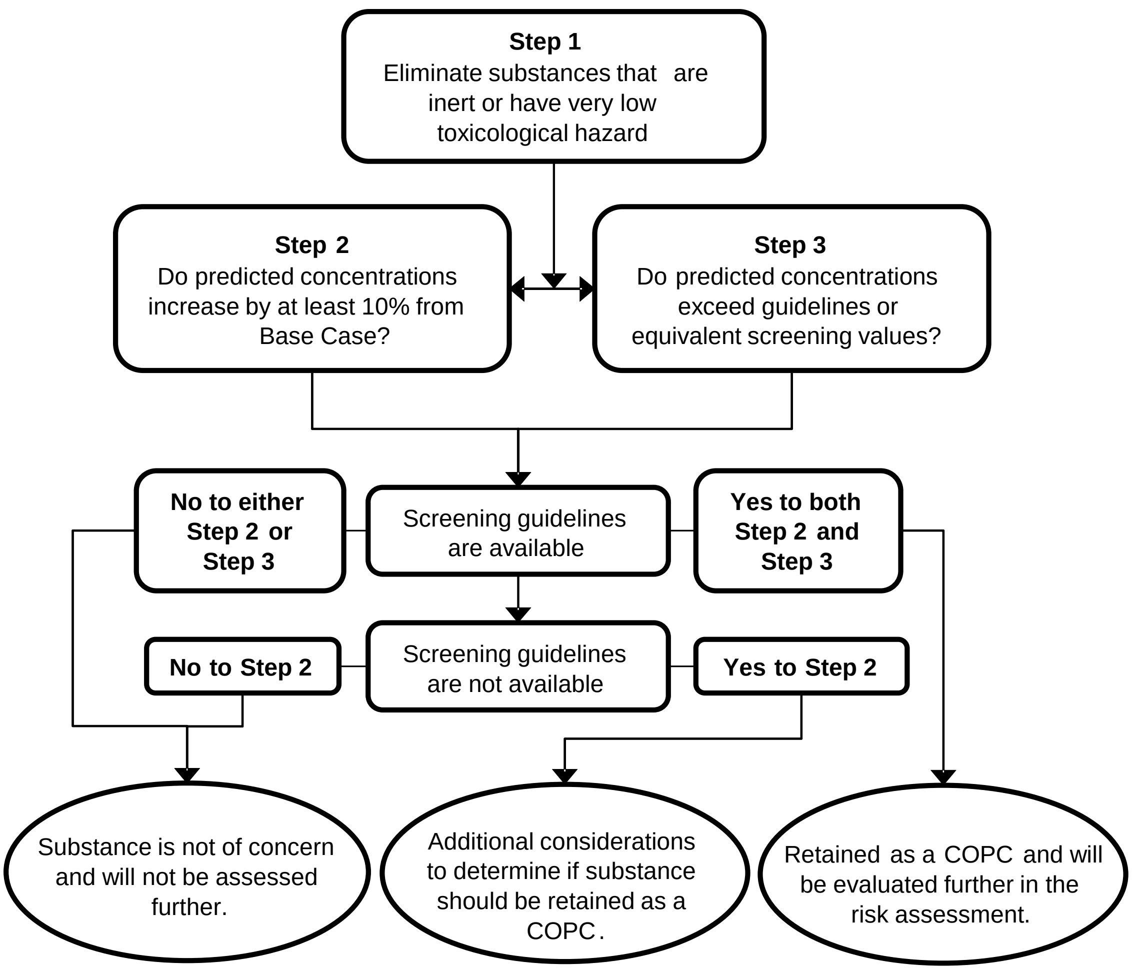
Non-Aboriginal Seasonal Users: Includes visitors to the lodges, hunting guides, non-Aboriginal community members that may attend meetings at the Diavik TK Camp, and users of the winter road rest stop. It was assumed that only adults and teenagers would access these camps on a regular or seasonal basis, and that hunting guides would be present in the ESA for the longest period (e.g., hunting season from August to October).

Mine workers: Includes mine workers in the ESA at the Diavik Camp, the Ekati Camp, and the Misery Camp. Although the workers are adults, teenage visitors to the mines were also considered.

4.2.1.2 Chemical Screening – Identification of COPCs

A screening process was used to determine the COPCs to be carried through the multimedia assessment for human health. The screening process was applied to relevant media (i.e., air, water, soil, and fish tissue) and followed a step-wise approach described in Figure 4.2-1. The substances that underwent the screening process were those that are expected to be released as a result of mine operation and included metals and PAHs.

Figure 4.2-1 Constituent Screening for the Multimedia Assessment



The screening process involved the following steps:

- **Step 1: Elimination of Inert COPCs -** Some trace elements (e.g., bromine, gold) and essential minerals (e.g., calcium, sodium) are commonly analyzed in environmental samples (as part of the standard suite of metals treated by the analytical method) but generally have low toxicological effect at typical concentrations found in the environment and even at industrial sites such as a mine. Many of these constituents are present in parent rock and soil materials and are present in a toxicologically inert form, and some are essential micro- and macro-nutrients. These inert substances were eliminated from further consideration.
- **Step 2: Comparison of Application Case to Base Case** – Predictions for the Base Case and the Application Case were compiled for comparison. The predictions were based on the water quality modelling conducted as part of the DAR, water-to-fish modelling using bioaccumulation factors (BAFs), or the aerial deposition to soil model described in Appendix D (Exposure parameters). For the soils, the maximum observed baseline concentration was used as the starting point for deposition modelling for the purposes of screening COPCs. Base and Application Case predictions were then made using the specific air deposition rates for each of these cases. Screening was conducted to determine the substances and media for which the predicted Application Case concentrations were greater than a 10% increase from the baseline concentrations.
- **Step 3: Comparison to Guidelines** – Predicted Application Case concentrations were compared to guidelines to determine if the predicted concentrations were of environmental concern in a particular medium.

The final selection of COPCs depended on whether environmental quality guidelines are available for the constituent. Where environmental quality guidelines were available, constituents for which the Application Case concentration (i) exceeded the guideline, and (ii) increased by more than 10% compared to the Base Case, were retained as COPCs. Where environmental quality guidelines were not available, then substances for which the Application Case concentration was more than 10% higher than the predicted Base Case concentration underwent further consideration to determine if they should be retained as COPCs. Additional considerations where guidelines were not available included information on the toxicity of a constituent, and screening of similar constituents for which guidelines were available. Application of these considerations is discussed, where necessary, in Appendix C.

Comparison to regulatory values was considered to represent a conservative evaluation of the potential for the predicted concentrations to cause adverse effects. Comparison to Base Case concentrations was included in the screening procedure to evaluate whether a measureable Project-related effect on environmental quality was likely to occur. Given temporal variability, variability in sampling and laboratory methods, and the uncertainty inherent in estimates from water, air, and soil quality models, any predicted increase of less than 10% above Base Case concentrations was considered unlikely to reflect a meaningful Project-related change in environmental quality.

Several metals that were COPCs in the human health and/or ecological risk assessment are known to exist in two or more forms in environmental media. For example, chromium exists in two oxidation states (chromate and chromite), and arsenic exists in organic (arsenosugars) and inorganic (elemental arsenic) forms. These different forms can have very different bioavailability and toxicity. In the absence of information about which forms are present in environmental samples, at the screening stage it was assumed that the entire amount was bioavailable and is present in the more toxic form. Mercury can exist as the inorganic form or as a methylated form (methyl mercury) with different bioavailability and toxicity. At the screening stage, it was assumed that the entire amount was bioavailable and present in the more toxic form (methyl mercury).

The detailed results of the COPC screening process, including comparison between Base Case and Application Case, comparison to guidelines, and final selection of COPCs, are presented in Appendix C. Arsenic, chromium, mercury, and selenium were retained as COPCs for the human health risk assessment. All four COPCs were retained based on the fish tissue screening, and no COPCs were identified in water or soil. Chromium was identified as a COPC in the air screening for chronic effects (Appendix B).

4.2.1.3 Exposure Pathways

The objective of the exposure pathway screening process is to identify potential routes by which people could be exposed to constituents and the relative significance of these pathways to total exposure. A constituent represents a potential health risk only if it can reach receptors through an exposure pathway at a concentration that could potentially lead to adverse effects. If there is no pathway for a constituent to reach a receptor, then there cannot be a risk, regardless of the constituent concentration.

The rationale for selection of exposure pathways for the multimedia risk assessment is provided in Table 4.2-1. The COPCs selected for the multimedia risk assessment were evaluated for each of the exposure pathways listed in Table 4.2-1.

Table 4.2-1 Exposure Pathways Evaluated in the Multimedia Human Health Risk Assessment

Exposure Pathway	Rationale
Inhalation of air	People may be exposed to airborne constituents released to air from the Project. A detailed evaluation of the air pathway was conducted as part of the air quality assessment (see Section 4.1); however, inhalation of air was also considered an operable pathway in contributing to overall daily dose of COPCs in the multimedia assessment.
Ingestion of water	People may be exposed to waterborne constituents via ingestion. Mine workers and visitors to the mines have access to treated potable drinking water; therefore, this pathway was not considered operable for workers. It was assumed that seasonal receptor (e.g., Aboriginals and non-Aboriginal hunters and fishers) obtained their drinking water from lakes, and could potentially be exposed to COPCs in Lac de Gras and Lac du Sauvage, the lakes with the greatest potential for effects from Project activities. Incidental ingestion of water may also occur while swimming; however, given that swimming would not occur frequently in these cold Arctic lakes, and that the volume of water ingested incidentally is minimal compared to the volume of drinking water consumed, this pathway was not considered significant and was not evaluated quantitatively.

Table 4.2-1 Exposure Pathways Evaluated in the Multimedia Human Health Risk Assessment

Exposure Pathway	Rationale
Dermal contact with water	People may be exposed to waterborne constituents dermally. It was assumed that seasonal users (e.g., hunters and fishers) would come into contact with surface water (obtained from lakes) while bathing or showering. Mine workers were assumed to have access to treated potable water for showering; therefore, this pathway was not considered operable for mine workers.
Ingestion and dermal contact with sediment	People may be exposed to sediments while conducting activities on and around lakes (e.g., fishing, gathering drinking water). Although Project related activities are not predicted to significantly affect sediment concentrations, exposure to sediments contributes to the overall daily dose of COPCs; therefore, this pathway was included in the multimedia assessment. Workers are not permitted to fish in the ESA, and would not be collecting potable water from lakes; therefore, this exposure pathway does not apply to workers.
Ingestion of soil	Airborne constituents may deposit to soil and people may incidentally ingest soil.
Dermal contact with soil	Airborne constituents may deposit to soil and people may come into dermal contact with soil.
Inhalation of dust	Airborne constituents may deposit to soil and people may inhale soil dust particulates.
Ingestion of fish	Waterborne constituents may bioaccumulate in fish (e.g., methyl mercury) and people may ingest the fish. Mine workers are not permitted to fish within the ESA; therefore, this pathway applied only to seasonal users.
Ingestion of berries and traditional plants	People may consume berries that have received airborne deposition or that have taken up constituents from the soil. Aboriginal receptors may also consume traditional use plants (e.g., Labrador tea) that have received airborne deposition or that have taken up chemicals from the soil. It was assumed that mine workers would not be harvesting berries and traditional plants while on the mine site.
Ingestion of game meat	People may consume animals harvested from within the ESA. Caribou meat is a staple of the diet of Aboriginal people in the region and wild meat can be a significant component of their overall meat intake. Caribou and snowshoe hare meat was used to represent the meat ingestion pathway for seasonal users. Mine workers are not permitted to hunt in the ESA.
Background dietary intake (i.e., ingestion of supermarket foods)	To quantify total daily dose of COPCs from all pathways, background exposure from dietary sources (e.g., supermarket food) was included in the human health risk assessment.

COPC = constituent of potential concern; ESA = effects study area.

Based on the COPC screening and exposure pathway assessment, seasonal users that hunt and fish in the vicinity of Lac du Sauvage and Lac de Gras (i.e., near Diavik TK Camp, Lac de Gras Hunting Camp, and the LDG winter road rest stop) are considered to have the highest potential exposure to COPCs in the ESA, and were retained as the primary receptors for the multimedia assessment. The following receptor locations or receptor groups were not evaluated quantitatively in the multimedia assessment:

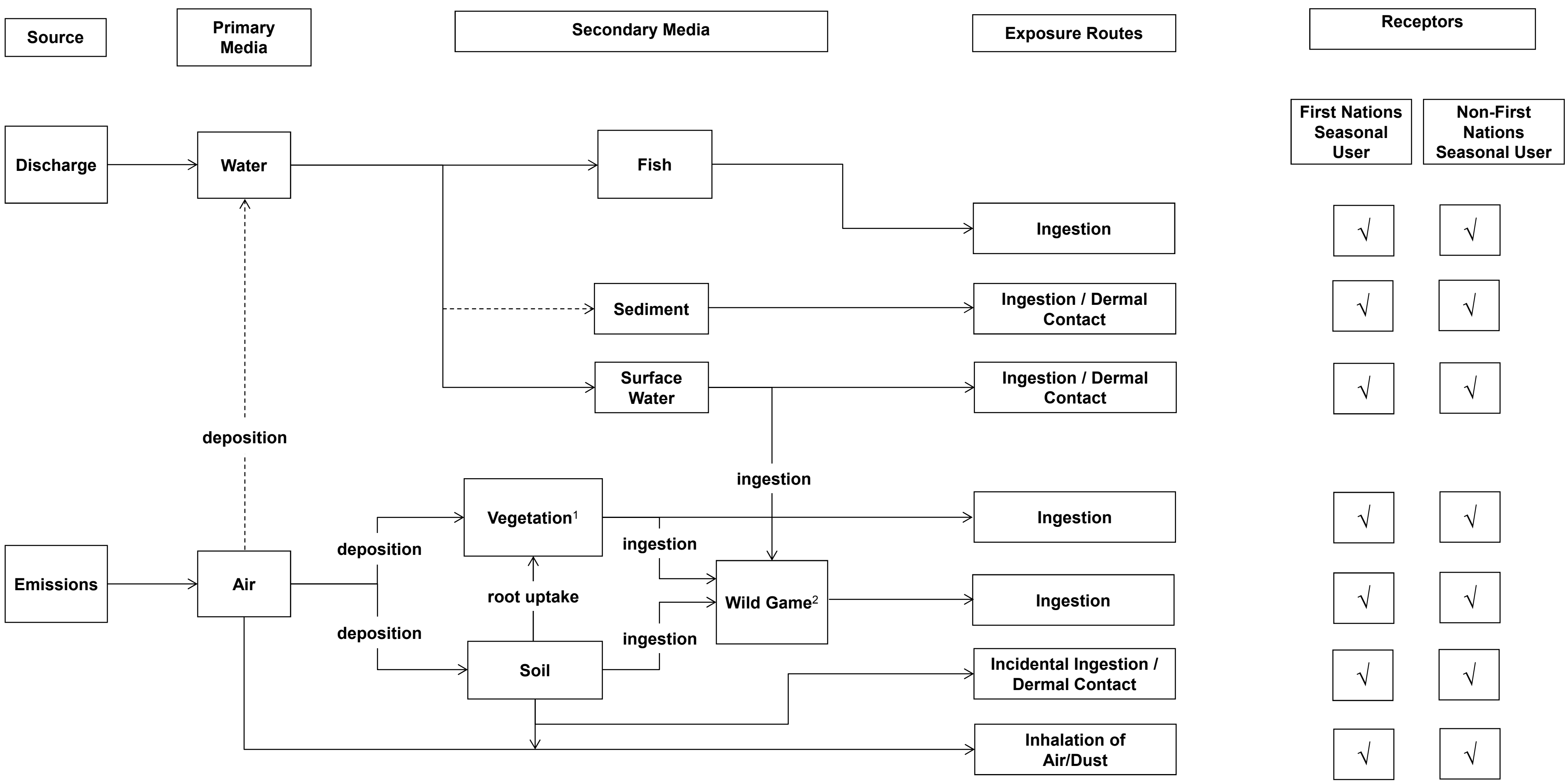
- **Mine workers:** Workers have access to treated drinking water, and are not permitted to hunt and fish in vicinity of the mine; therefore, the water, sediment, fish and game pathways do not apply. Exposure to soil would also be limited given that workers would be wearing personal protective equipment (e.g., gloves). Exposure to air and particulate matter is the most significant pathway for mine workers, and this pathway has been evaluated in detail in the air quality assessment and particulate matter assessment.
- **Courageous Lake Lodge, Treeline Lodge, Salmita Airstrip:** Seasonal users at these locations have a much lower potential for exposure to COPCs compared to receptors next to Lac de Gras and Lac du Sauvage. Water and fish quality are unlikely to be affected in the southern portion of the ESA,

as these waterbodies are not directly connected to the areas of greatest effects (i.e., Lac de Gras and Lac du Sauvage). Furthermore, effects on soil, vegetation, and game are also much lower in this area based on their distance to the mines (e.g., deposition rates were lower at these locations compared to receptor locations close to the mine). If risks are found to be acceptable for seasonal receptors closer to the mine, then risks would also be considered acceptable at these locations.

- **Pellatt Lake cabin:** Similar to the receptor location at the south of the ESA, seasonal users at the Pelatt Lake Cabin, in the north of the ESA would be much less exposed to Project-related COPCs in comparison to receptor locations closer to the mines. Water, fish, and sediment pathways would not apply, given that Pellatt Lake would not be influenced by the Project. Soil, vegetation, and game effects would also be minimal compared to locations closer to the mines, as demonstrated by the lower deposition rates at this location. Air quality was evaluated at this location as part of the air quality assessment. If risks are acceptable for seasonal receptors closer to the mine, then risks would also be considered acceptable at the Pellatt Lake cabin.

In summary, seasonal receptors that hunt and fish close to the mine (i.e., in the vicinity of Diavik TK Camp, LDG Hunting Camp, and the LDG winter road rest stop) were considered to have the “worst-case” exposure to Project-related COPCs, and evaluation of these receptor groups was considered protective of the remaining seasonal users. A multimedia exposure assessment was not conducted for mine workers, given that most exposure pathways do not apply to these receptors, and the exposure to COPCs in air (the most significant pathway) was conducted as part of the air quality and particulate matter assessment.

Further details on exposure and receptor assumptions are provided in Appendix D. A conceptual exposure model is provided in Figure 4.2-2, and summarizes the potential interactions of COPCs, exposure pathways, receptors of concern evaluated in the human health risk assessment.



Legend

√ Complete Exposure Pathway

X Not Applicable Pathway

- - - - - Incomplete Pathway (i.e., no impact related to the Project)

1 – Leaves, berries , and Labrador tea (for human and/or wild game consumption); 2 – Caribou, Hare

Human Health Conceptual Exposure Model for the Multi-Media Risk Assessment
Dominion Jay Project

Golder Associates

PROJECT No.140726			FILE No. ----
DESIGN	LM	16Dec14	SCALE NTS REV.
CHECK	TZ	30Jan15	**FIGURE 4.2-2**
REVIEW	AW	30Jan15	

4.2.2 Toxicity Assessment

The toxicity assessment provides the basis for evaluating what an acceptable exposure is and what level of exposure may adversely affect people's health. The toxicity assessment for the multimedia risk assessment is based on long-term (chronic) toxicity studies. Toxicity assessment involves determining the amount of a constituent a person may consume from applicable exposure pathways without it affecting their health. A toxicity reference value is the amount of chemical that person may be exposed to on a daily basis for their lifetime without adverse health effects.

For the multimedia risk assessment, TRVs for non-carcinogenic chemicals are called reference doses (RfDs) for the oral pathway and reference concentrations for the inhalation pathway. For carcinogenic chemicals, TRVs are called slope factors (SF) for the oral pathway and inhalation unit risks (IURs) for the inhalation pathway. The TRVs were obtained from the following agencies:

- Health Canada;
- US EPA's Integrated Risk Information System;
- World Health Organization (WHO);
- Agency of Toxic Substances and Disease (ATSDR) Registry Minimal Risk Levels;
- California Environmental Protection Agency (Cal EPA); and,
- Netherlands National Institute of Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu).

The available and selected TRVs and their toxicological basis are presented in Appendix E.

4.2.2.1 Carcinogenicity Classification

Among the COPCs retained for the multimedia risk assessment, arsenic is classified as a carcinogen through the oral and inhalation pathways, and chromium (hexavalent speciation) is classified as a carcinogen through the inhalation pathway only. Further detail on the chemical classifications for the COPCs retained in the human health multimedia assessment is available in Appendix E.

4.2.2.2 Toxicity of Mixtures

Toxicity of chemical mixtures was addressed by summing hazard quotients and ILCR values for COPCs that contribute to the same type of toxic effect as discussed in Section 5.2 below.

4.2.3 Exposure Assessment

An exposure assessment is the process of estimating the amount of a chemical that a person consumes (referred to as a dose) or inhales (referred to as a concentration) through applicable exposure pathways on a daily basis for their lifetime. The dose of a chemical depends on the concentrations in various media (e.g., water, soil, food), the amount of time a person is in contact with these media, and the biological characteristics of the person (e.g., ingestion rates, body weights, dietary preferences).

Receptor and exposure assumptions, exposure equations, and the methods used to predict concentrations in soil, plants, meat and fish are presented in Appendix D.

4.2.3.1 Exposure Concentrations

The following data were used to determine concentrations of COPCs in various environmental media:

- predicted annual air concentrations at receptor locations for the Base and Application Cases;
- predicted annual air deposition rates at receptor locations for the Base and Application Cases;
- predicted soil, plant, and game meat concentrations based on air emissions data for the Base and Application Cases;
- measured baseline and predicted surface water concentrations in Lac du Sauvage and Lac de Gras;
- sediment concentrations measured in the ESA during baseline surveys;
- predicted fish tissue concentrations from Lac du Sauvage and Lac de Gras; and,
- background dietary intake values (i.e., for supermarket foods).

For the multimedia assessment, it was assumed that a seasonal user (Aboriginals and non-Aboriginals) would be in the vicinity of Lac de Gras and Lac du Sauvage for up to three months of the year to participate in hunting and fishing activities. Maximum air quality and deposition predictions from the Lac de Gras hunting camp, Diavik TK camp, and LDG winter road rest stop receptor locations (see Map I-1, Appendix I) were selected to predict exposure concentrations in air, soil, vegetation, and meat. These locations exhibited the highest deposition rates (outside of the mines), and were therefore considered appropriate to estimate the “worst-case” exposure concentrations. The maximum predicted water and fish tissue concentrations over time from stations across Lac de Gras and Lac du Sauvage were conservatively used to estimate Application Case exposure concentrations for the surface water ingestion, surface water dermal contact, and fish consumption pathways. More detail on the estimation of exposure concentrations is provided in Appendix D.

4.2.3.2 Exposure Equations

For the multimedia assessment, oral and dermal exposure is determined as a dose; this value is called the estimated daily intake (EDI) and is typically expressed as milligrams of chemical per kilogram of body weight per day (mg/kg BW/day. For the inhalation pathway, exposure is determined as a concentration; this value is called the estimated concentration and is typically expressed as mg/m^3. Equations used to calculate the EDI and estimated concentration for the multimedia risk assessment are provided in Appendix D.

4.2.4 Risk Characterization

In the risk characterization step, long-term health effects were evaluated by calculating HQs for chemicals that do not cause cancer (non-carcinogens) and ILCR values for chemicals that are suspected to cause cancer (carcinogens).

Hazard Quotients for the Base Case and Application Case were calculated for each COPC by comparing the predicted levels of exposure with the exposure limits according to the following equations:

$$HQ = \frac{\text{estimated daily intake}\left(\text{mg/kg BW/day}\right)}{\text{RfD (mg/kg BW/day)}}$$

or

$$HQ = \frac{\text{estimated air concentration} \quad (\mu g/m^3)}{\text{RfC} \ (\mu g/m^3)}$$

An HQ less than or equal to 1.0 indicates that the estimated exposure is less than the reference dose, signifying negligible health effects. When the HQ for a particular scenario is greater than 1.0, then that scenario poses a potential concern and requires further investigation. However, HQ values greater than 1.0 do not necessarily indicate that adverse health effects will occur because of the margin of safety that is included in their estimation.

Pathway-specific HQs were summed to give a total HQ value for multimedia exposure.

For carcinogens, risk estimates are based on the ILCR, which is the additional cancer cases attributed to the incremental exposures to carcinogens released by the Project. Interpretation of these ILCRs was based on comparison of the calculated ILCR values with the “benchmark” of 1 in 100,000 (i.e., one extra cancer case in a population of 100,000 people).

For carcinogenic COPCs, ILCRs for the Base Case and Application Case were calculated according to the following equations:

$$\text{ILCR (oral/dermal pathways)} = \text{estimated daily intake (mg/kg BW/day)} \times \text{SF (mg/kg/d)}^{-1}$$

or

$$\text{ILCR (inhalation pathways)} = \text{estimated air concentrations } (\mu g/m^3) \times \text{inhalation unit risk } (\mu g/m^3)^{-1}$$

Pathway-specific ILCRs were summed to give a total ILCR value for multimedia exposure.

4.2.4.1 Constituent Mixtures

The HQs for COPCs for which TRVs were based on similar target organs were added together to determine a total HQs for similar toxicological effects (Health Canada 2010b). Likewise, ILCRs are summed for carcinogenic COPCs with the same target organ and form of cancer. The COPCs for which HQs and ILCRs were summed by target organ endpoints are shown in Table 4.2-2. For details on the target organ(s) and effect(s) of each COPC, see Appendix E.

Table 4.2-2 Potential Additive Interactions of the Constituents of Potential Concern for the Human Health Multimedia Risk Assessment

Constituent of Potential Concern		Target Organ	Effects
Carcinogens	Arsenic and chromium (inhalation pathways only)	Respiratory tract	Lung tumours

Non-carcinogenic COPCs did not exhibit similar toxicological effects and were not summed.

4.2.5 Uncertainty

Uncertainty is associated with estimating potential health risks. When information is uncertain, it is standard practice in a risk assessment to make assumptions that are biased towards safety (i.e., conservative assumptions), so that even if there is uncertainty, human health will still be protected.

The main areas of uncertainty associated with this analysis include the following:

- representativeness of existing baseline data for depicting relevant exposure concentrations;
- the uncertainty inherent in the aerial deposition model;
- uncertainty inherent to the modelling associated with the prediction of incremental changes in soil, plants, and meat;
- uptake factors for chemicals from soil to plants and multimedia sources to meat tissue (for chemicals for which site-specific data were not available);
- consumption rates of foods; and,
- uncertainty associated with estimating TRVs.

In summary, while there is some uncertainty in the estimation of health effects, there is considerable confidence that the risks have not been underestimated because of the conservative assumptions employed.

4.3 Wildlife Health – Multimedia Assessment

4.3.1 Problem Formulation

The problem formulation step involved determining the receptors, constituents, and exposure pathways of greatest concern for the multimedia risk assessment.

4.3.1.1 Potential Receptors

The objective of this step was to select a representative set of wildlife receptors that may be exposed to chemicals emitted by the Project to terrestrial and aquatic environments in the ESA. Representative receptors are those that have the greatest potential for exposure, play a key role in the food web, are a surrogate for their respective feeding guild, and have sufficient characterization data to facilitate calculations of exposure and health risks. The list of potential receptors for wildlife was selected from the VCs identified in Section 1.3 and was identified considering the following:

- the Key Lines of Inquiry and Subjects of Note in the Terms of Reference for the Project;
- wildlife species that have been identified as being present in or migrating through the ESA by the Wildlife and Wildlife Habitat discipline;
- wildlife species expected to be present and that are listed as Special Concern, Threatened or Endangered by Committee on the Status of Endangered Wildlife in Canada, *Species at Risk Act*, or NWT Species at Risk; and,
- wildlife species that are representative of specific feeding guilds and food web components (e.g., herbivore, insectivore, carnivore) and habitats (e.g., aquatic, terrestrial), where these guilds/components were not already represented in the categories above.

The preliminary list of potential receptors included:

- Barren-ground Caribou;
- Grizzly bear;
- Wolverine;
- Gray wolf;
- Barren ground shrew;
- Meadow vole;
- Musk oxen;
- Moose;
- Arctic fox;
- Muskrat;
- American robin;
- Willow ptarmigan;
- Common raven;
- Short-eared owl;
- Peregrine Falcon;
- Green-winged teal;
- Semi-palmated sandpiper;
- Rusty blackbird;
- Common merganser; and,
- Bald eagle.

Table 1.3-1 provides additional rationale for the selection of each species. This list of potential receptors was refined, as appropriate following the identification of constituents of potential concern (Section 4.3.1.2, below). Final selection of wildlife receptors for quantitative risk assessment considered the habitats (i.e., aquatic or terrestrial) for which constituents of potential concern were identified.

4.3.1.2 Constituents of Potential Concern

A similar screening method to that used in the human health multimedia risk assessment was conducted for the wildlife health risk assessment where predicted water, soil, and fish tissue concentrations were screened for COPCs. Metals and PAHs were screened against applicable guidelines for wildlife health. Where guidelines were available, constituents for which the Application Case concentrations (i) exceeded the guideline, and (ii) were greater than 10% higher than baseline, were retained as COPCs. Where guidelines were not available, then constituents for which the Application Case concentrations were more than 10% higher than the predicted baseline concentration underwent further consideration to determine if they should be retained as COPCs. Additional considerations where guidelines were not available included information on the toxicity of a substance, and screening of similar substances for which guidelines were available. Application of these considerations is discussed, as applicable in Appendix C.

Based on the screening process outlined in the preceding paragraph (and in Section 4.2.1.2), arsenic, chromium, mercury (as methyl mercury), and selenium were retained as COPCs for the wildlife health risk assessment. These constituents were only identified as COPCs for fish tissue (representative of aquatic prey items). In Lac de Gras East (LDG East) and Lac de Gras West (LDG West), predicted arsenic, chromium, mercury tissue concentrations exceeded applicable fish tissue guidelines and increased by greater than 10% compared to predicted Base Case concentrations under all scenarios (under ice and open water). Fish tissue concentrations for selenium in LDG East (under ice and open water) and in LDG West (under ice) scenarios exceeded the applicable fish tissue guidelines and increased by greater than 10% compared to predicted Base Case concentrations.

Wildlife COPCs were only identified for aquatic habitats in the ESA. As a result, terrestrial receptors were eliminated as receptors in the wildlife health risk assessment and only aquatic-feeding receptors were retained for further evaluation.

4.3.1.3 Final Receptor Screening

The screening process for soils and surface water did not identify COPCs for the environments and drinking water sources that would be used by terrestrial wildlife receptors listed in Section 1.3.2. Therefore, the exposure assessment, toxicity assessment, and risk characterization for wildlife health was limited to caribou (because it is a KLOI for the Project) and on those wildlife receptors feeding and inhabiting aquatic environments in the ESA. The receptors for the multimedia assessment included:

- Caribou;
- Grizzly bear;
- Muskrat;
- Rusty blackbird;
- Common merganser;
- Green-winged teal;
- Semi-palmated sandpiper; and
- Bald eagle.

Caribou feed only in the terrestrial environment (primarily on lichen), but were retained in quantitative multimedia health assessment because they are a KLOI for the Project. Caribou muscle tissue concentrations were also modelled in the wildlife food chain model, for inclusion as prey for carnivores and to represent wild game in the human health risk assessment. For the wildlife health assessment, soil, willow/birch leaves, and lichen exposure concentrations for the caribou were based on the maximum concentrations predicted at the MPOI. For the human health assessment, soil, willow/birch leaves, and lichen exposure concentrations for the caribou were based on the maximum concentrations from the following three locations, which were evaluated in the human health risk assessment: Diavik TK Camp, LDG winter road rest stop, and LDG Hunting Camp.

The remaining receptors feed, at least in part, in the aquatic environment and, therefore, were retained as receptors for the wildlife multimedia assessment.

Table 4.3-1 provides detail of the ecology for each receptor including considerations related to the multimedia food chain modelling. Additional receptor parameters are provided in Appendix D.

Table 4.3-1 Wildlife Receptors Considered for the Wildlife Health Risk Assessment

Valued Component	Ecological Niche	Rationale for Selection
Barren-ground caribou (*Rangifer tarandus groenlandicus*)	Terrestrial herbivore	• Barren-ground caribou are an important cultural and economic resource for people in the NWT, and were identified as a valued component in the Terms of Reference. • The Canadian form of the barren-ground caribou is the most common caribou in Canada (EC & CWF 2013a; NWT 2015). The migratory barren-ground caribou spend most of the year on the tundra, but make migrations southward in the fall from the tundra to the taiga (hundreds of kilometres) and northward in the springtime to their small calving grounds and summer range on the tundra. The Bathurst caribou herd occupies a range of approximately 231,000 km^2 (Gunn et al. 2013) and is known to migrate through or inhabit the Ekati region at certain times of the year. • The caribou diet consists of lichens, flowers, grasses, and leaves of shrubs depending on seasonal availability, but lichens are the caribou's primary food source for much of the year (EC & CWF 2013a). Caribou may also utilize lick sites as a source of salt and have been observed to "binge" on tailings at other mine sites in the NWT (MacDonald and Gunn 2004). However, this pathway was considered to have no linkage for this Project because fine processed kimberlite will not be accessible by caribou.
<u>Grizzly bear</u> (*Ursus arctos*)	Aquatic/ Terrestrial Omnivore	• As large omnivores, plants, such as grasses, sedges, and berries, are a main staple of a grizzly bear's diet; however, they will also hunt large herbivores such as caribou, moose, muskoxen and sheep, small mammals such as lemmings and ground squirrels, and fish (Government of NWT 2013; NWF 2015). In the NWT, grizzly bears mainly occupy open tundra or alpine habitats. They have a large home range area, extending to over 2,000 km^2 for males and half of that for females (Government of NWT 2013). Grizzly bears will generally avoid human contact due to their solitary nature. However, human activities tend to disturb their natural habitat and could cause them to abandon large sections of their home range (Government of NWT 2013). Grizzly bears are listed as "sensitive" in the NWT (Government of NWT 2013) and as 'Special Concern' by COSEWIC as of May 2012 (COSEWIC 2012).Throughout the winter, grizzly bears hibernate in dens. As the snow melts, grizzly bears will venture out from their dens to search for food. The summer and fall are prime feeding times for grizzly bears to build up fat reserves to prepare for winter hibernation (NWF 2015).

Table 4.3-1 Wildlife Receptors Considered for the Wildlife Health Risk Assessment

Valued Component	Ecological Niche	Rationale for Selection
Muskrat (*Ondatra zibethicus*)	Aquatic/ Terrestrial Omnivore	• The muskrat is a large rodent that is adapted to life in the water. They typically live in freshwater marshes, marshy areas of lakes, and slow-moving streams due to their preference for eating cattails, horsetails, or pondweeds and other plants and contain ideal building materials for their home (EC & CWF 2013b). Compact mounds of partially dried and decayed plant material are used as building materials, and most importantly, the water must be deep enough so that it will not freeze to the bottom in the winter but shallow enough so to permit growth of vegetation (EC & CWF 2013b). • During the winter, muskrats spend most of their time sleeping and feeding in their lodge and travelling to and from their feeding stations on the ice (EC & CWF 2013b).
Rusty blackbird (*Euphagus carolinus*)	Aquatic omnivore	• The rusty blackbird is categorized as "Special Concern" by COSEWIC (COSEWIC 2006) and by the Federal Species at Risk Act (Government of Canada 2014). It is categorized as No Status on NWT's List of Species at Risk but it is ranked as Sensitive on NWT's General Status Rank. Rusty blackbirds are found in wet forests, including areas with fens, bogs, muskegs, and beaver ponds located north of the treeline in Canada and Alaska during their breeding season. They winter in the southeastern portion of the United States in swamps, wet woodlands, and pond edges (Avery 2013). As opportunistic feeders, they will feed on crops (corn, oats, wheat) and weed seeds, grape, blackberry, elderberry, oak, and beech in the winter and during migration (Avery 2013). Throughout the year, they will eat invertebrates such as aquatic beetles, grasshoppers, spiders, snails and crawfish, and small vertebrates such as salamanders and small fish (Avery 2013).
Common merganser (*Mergus merganser*)	Avian omnivore	• Common mergansers are large ducks found in streams, rivers, lakes, coastal bays, and estuaries. Adult mergansers mainly eat fish during the winter season, whereas during the breeding season, frogs, small mammals, other birds, and plants are consumed. Nestlings will eat aquatic invertebrates such as insects, mollusks, crustaceans and worms (Mallory and Metz 1999). In the winter, mergansers migrate south to the United States and they migrate north to the northern portions of the Canadian provinces and to the southern portions of the Canadian territories during the summer and breeding season (Mallory and Metz 1999). The common merganser is not listed on COSEWIC or as a species at risk in the NWT.
Green-winged teal (*Anas crecca*)	Avian herbivore	• The green-winged teal is North America's smallest dabbling duck. They prefer shallow, marshy habitats, tidal creeks, and mudflats with abundant vegetation as that is their preferred food source (Johnson 1995). The teal breeds throughout Canada, Alaska, and the northern US Great Plains and winters along the Pacific coast from Alaska all the way down the American coastline to Mexico and the Caribbean (DUC 2014). Populations of the green-winged teal appear stable (DUC 2014). The green-winged teal is not listed on COSEWIC or as a species at risk in the NWT.
Semi-palmated sandpiper (*Calidris pusilla*)	Avian insectivore	• The semi-palmated sandpiper is one of Canada's smallest shorebirds (EC & CWF 2013c). The sandpiper has a very long seasonal migration, often covering more than 3,000 km non-stop from the northern parts of South America during the winter season to their breeding grounds in sub- and mid-arctic areas of Canada and Alaska in May each year (EC & CWF 2013c). Their preferred breeding grounds are on open tundra, generally near water (Gratto-Trevor 1992). They mainly feed on aquatic invertebrates by foraging in shallow waterbodies and mudflats (Gratto-Trevor 1992). The semi-palmated sandpiper is not listed on COSEWIC or as a species at risk in the NWT.

Table 4.3-1 Wildlife Receptors Considered for the Wildlife Health Risk Assessment

Valued Component	Ecological Niche	Rationale for Selection
Bald eagle (*Haliaeetus leucocephalus*)	Avian Piscivore/ Carnivore	• As long-distance migrants, bald eagles are capable of flying hundreds of miles a day (Buehler 2000). They typical nest in forested areas adjacent to large bodies of water away from human activities but are tolerant of human activity when feeding. In the winter, they can be observed in dry, open uplands as long as open waterbodies nearby. During the breeding season, they are observed throughout Canada and Alaska. During the winter season, they can be found in the United States and northern Mexico (Buehler 2000). Fish is a main constituent of a bald eagle's diet, but rather than fishing themselves, bald eagles will harass other birds and mammals for their catch (Buehler 2000). Bald eagles they are also known to consume birds, reptiles, amphibians, crabs, rabbits, and muskrats (Buehler 2000). • Due to their stable populations, bald eagles are listed as "Not at Risk" on COSEWIC and are not considered as a species at risk in the NWT.

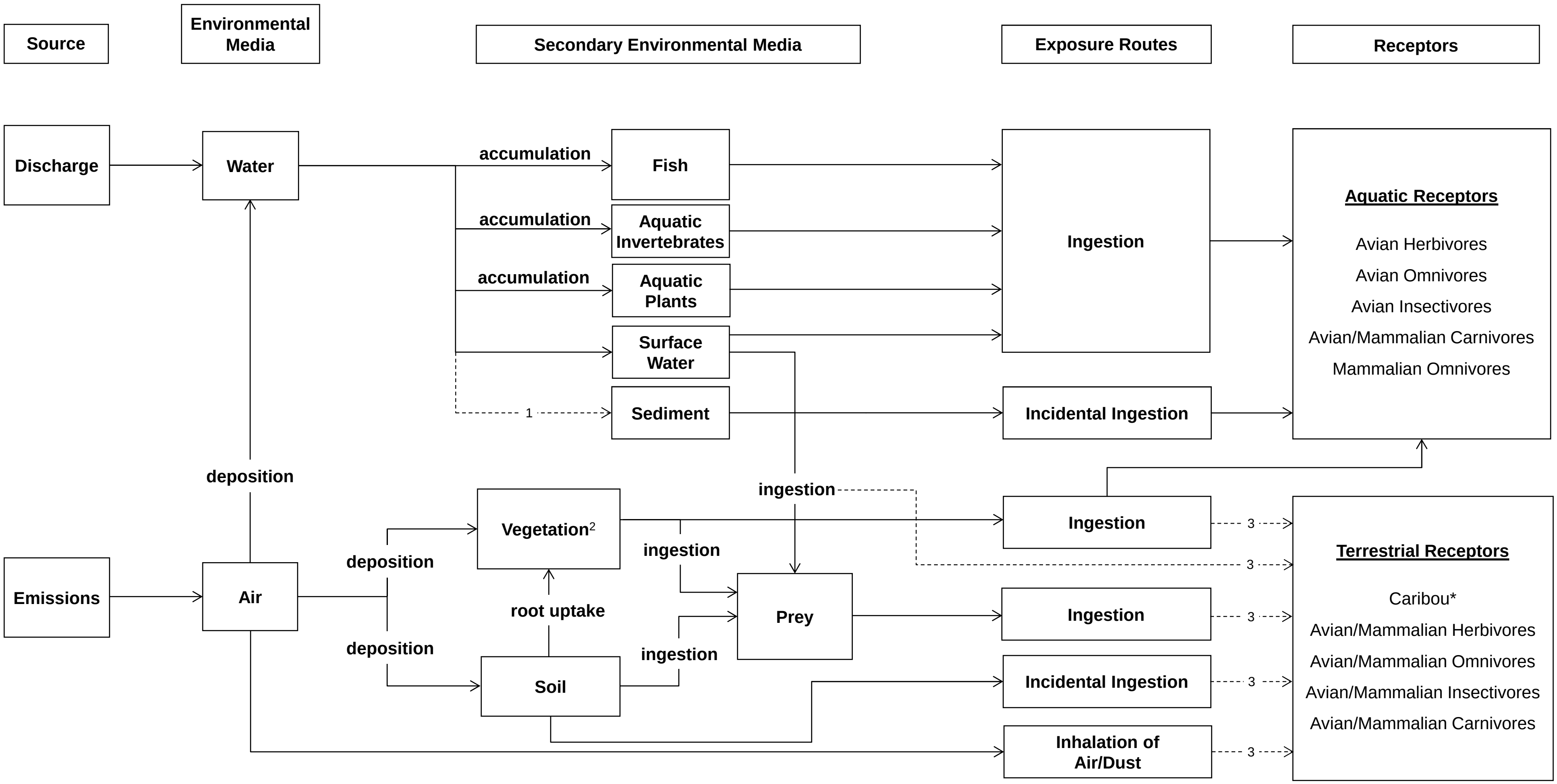
Note: <u>Underlined</u> = Species at risk.

COSEWIC = Committee on the Status of Endangered Wildlife in Canada; NWT = Northwest Territories.

4.3.1.4 Exposure Pathways

The objective of the exposure pathway screening was to identify potential pathways by which wildlife could be exposed to COPCs and the relative significance of these pathways to total exposure. A constituent presents a potential health risk to wildlife 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 constituent to reach a receptor, then there cannot be a risk, regardless of the constituent concentration.

A conceptual exposure model is provided in Figure 4.3-1, and summarizes the potential interactions of COPCs, exposure pathways, and receptors of concern evaluated in the wildlife health risk assessment. Each of these exposure pathways is described in Table 4.3-2. Further details on exposure and receptor assumptions are provided in Appendix D.



Legend

⟶ Complete Exposure Pathway

- - - -> No Impact Related to the Project

1 - There is not anticipated to be any Project impact on substance concentrations in sediments, but baseline concentrations of COPCs were included for the incidental sediment ingestion pathway for aquatic-feeding wildlife receptors
2 - Vegetation includes berries, grasses, lichen, and willow/birch leaves.
3 - There are no COPCS for these pathways and therefore, with the exception of caribou, a quantitative multiemdia risk assessment was not conducted for terrestrial-feeding wildlife receptors.
*Caribou were retained in the quantitative multimedia risk assessment because they are a Key Line of Inquiry

Wildlife Health Conceptual Model for the Multi-Media Risk Assessment
Dominion Jay Project

Golder Associates

PROJECT No.140726			FILE No. ----	
DESIGN	RWS	16Dec14	SCALE NTS	REV.
CHECK	SK	30Jan15	**FIGURE 4.3-1**	
REVIEW	AW	30Jan15		

Table 4.3-2 Exposure Pathway Screening

Exposure Pathway	Evaluated	Rationale
Inhalation of air/dust	X	Air and dust inhalation by wildlife is not usually assessed in ecological risk assessments. Toxicity reference values for chemicals that specifically address the inhalation pathway in wildlife are limited in the literature and those studies that are available have not typically been designed to distinguish between exposure resulting from inhalation and the dietary components due to deposition (BC MoELP 2000). In most situations, the air and dust inhalation pathway is considered negligible relative to the oral ingestion pathway (which includes incidental ingestion of fine particulates) and the amount of exposure excluded by not including inhalation would be small (Sample et al. 1997; BC MoELP 2000).
Ingestion of surface water	✓	Surface water serves as the drinking water source for caribou and aquatic-feeding wildlife. Consumption of Base Case and Application Case water concentrations was included as an exposure pathway for the wildlife receptors evaluated in the wildlife health risk assessment.
Dermal contact with surface water	X	Although wildlife have direct dermal contact with surface water, birds and mammals likely receive insignificant doses through this route relative to other routes, such as direct ingestion of water (Environment Canada 1994). Therefore, the dermal exposure to surface water pathway was not evaluated for the wildlife health assessment.
Ingestion of fish	✓	Aquatic-feeding wildlife consume fish which may accumulate COPCs through the water pathway; therefore the ingestion of fish pathway is evaluated in the wildlife health assessment.
Ingestion of aquatic plants	✓	Aquatic-feeding wildlife receptors ingest aquatic plants, which may accumulate COPCs through the water pathway. Therefore, this exposure pathway was evaluated in the wildlife health assessment. This pathway was included for the caribou, and for other receptors that feed partially on aquatic plants. .
Ingestion of aquatic invertebrates	✓	Aquatic-feeding wildlife ingest aquatic invertebrates, which may accumulate COPCs through the water pathway. Therefore, this exposure pathway was evaluated in the wildlife health assessment.
Ingestion of sediment	✓	Aquatic-feeding wildlife may consume small amounts of sediment while foraging, preening, and grooming. Therefore, this exposure pathway was evaluated in the wildlife health assessment.
Ingestion of soil	✓	During the operations phase, airborne emissions from the Project may deposit directly onto soil. Terrestrial-feeding species consume small amounts of soil during foraging, preening, and grooming. This pathway was included for the caribou and for the grizzly bear. The other aquatic-feeding receptors would consume sediment rather than soils Bald eagles consume negligible amounts of soil or sediment.
Ingestion of terrestrial plants	✓	During the operations phase, airborne emissions from the Project may deposit directly onto plant surfaces (terrestrial and aquatic) and soils. Constituents may subsequently be taken up into plants that are food sources for wildlife. Consumption of terrestrial plants could expose wildlife to chemicals. This pathway was included for the caribou, and for other receptors that feed partially on terrestrial plants.
Ingestion of avian/mammalian prey	✓	Carnivorous and omnivorous animals have the potential to be exposed to chemicals via ingestion of prey. The ingestion of prey pathway was included for the grizzly bear (terrestrial omnivore, occasionally hunts caribou and small mammals) and the bald eagle (occasionally consumes terrestrial small mammals. Other terrestrial-feeding carnivore receptors were not retained for the risk assessment).

COPC = constituent of potential concern; ✓ = evaluated; X = not evaluated.

4.3.1.5 Summary of Problem Formulation

Table 4.3-3 provides a summary of the receptors and relevant exposure pathways that will be evaluated in the risk assessment for each COPC.

Table 4.3-3 Receptors and Exposure Pathways Evaluated in the Wildlife Health Assessment

Receptor	Soil	Surface Water	Terrestrial Plants	Avian/Mammalian Prey	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish
Mammals								
Caribou	✓	✓	✓	X	X	✓	X	X
Grizzly Bear	✓	✓	✓	✓	X	✓	X	✓
Muskrat	X	✓	✓	X	✓	✓	✓	✓
Birds								
Rusty blackbird	X	✓	✓	X	✓	X	✓	✓
Common merganser	X	✓	X	X	✓	✓	✓	✓
Green-winged teal	X	✓	X	X	✓	✓	✓	X
Semi-palmated sandpiper	X	✓	X	X	✓	X	✓	X
Bald eagle	X	✓	X	✓	X	X	X	✓

✓ = evaluated; X = not evaluated.

4.3.2 Exposure Assessment

Dietary exposures to COPCs were modelled using a simplified food web to represent the wildlife receptors identified in the problem formulation. Mathematical models describing COPC fate and uptake were combined in a multimedia food web model to assess exposure-effects relationships for each combination of receptor and COPC. A total EDI integrating the dietary exposure from all dietary items was calculated for each COPC and receptor. The basic equation for the food web model was as follows:

$$EDI = \frac{\sum \mathrm{IR_m} \cdot \mathrm{C_m}}{BW} \times AF$$

Where:

EDI = estimated daily intake (mg/kg body weight/day);

IR_m = ingestion rate of prey and media (kg/day dry weight);

C_m = concentration of COPC in media/food consumed (mg/kg dry weight);

AF = absorption factor (unitless); and

BW = body weight (kg wet weight).

The equations used to estimate the ingestion rates for each receptor and food item, the concentration estimates for each prey item m, and other modelling parameters are provided in Appendix D.
The resulting EDI represents the exposure for each COPC and receptor combination.

Concentrations for each COPC were derived from measurements taken in the ESA or represent estimated values based on summing existing conditions and model-projected increases. The multimedia food web model includes wildlife exposure via food and incidental soil or sediment ingestion.
Potential food sources (depending on feeding preferences) include water, aquatic and terrestrial vegetation, aquatic invertebrates, terrestrial invertebrates (earthworms), fish, and terrestrial mammals.

Water quality, soil quality, and dust deposition rates were combined with bioconcentration or bioaccumulation factors to estimate metals concentrations on and in vegetation, in invertebrate tissues, and in fish tissues. Uptake factors or bio-transfer factors were used to estimate the uptake into tissues of small mammals to provide an estimate of the dietary exposure for higher predators.

To represent potential worst-case conditions, EDI estimates were made for each COPC/receptor combination based on highest aerial deposition scenarios for the Project area, which was typically either the fenceline or the MPOI.

4.3.2.1 Concentrations of Constituents of Potential Concern in Source Media and Fish

Exposure of wildlife receptors to COPCs was estimated using concentrations of COPCs in source media (e.g., soil, vegetation, water, and fish tissue). Estimates of existing COPC concentrations in source media were derived from laboratory analyses of samples from the ESA.

The approach used to calculate point estimates for source media and fish tissue for each assessment case, often using upper-bound estimates, is presented in Table 4.3-4. The approach is conservative, because the mobility of most wildlife species (i.e., home range and migratory habits of most species present in the vicinity of the Project) would result in exposure to a wider range of COPC concentrations that will be closer to the mean exposure concentrations across the ESA, rather than upper-bound exposures in the ESA (i.e., based on maximum deposition rates and maximum annual average water concentrations). In addition, wildlife species would be exposed to background concentrations of metals and contaminants even when not in the Project area. Thus, to be conservative and to protect organisms with more localized sub-habitats, the upper-bound estimates were applied.

Deposition and accumulation equations were applied to predict changes to metals concentrations in soil, vegetation, and fish, invertebrate and small mammal tissue (either directly or through application of a bioaccumulation factor) that may result from changes to air and/or water quality. Changes to water concentrations were based directly on the model predictions generated by the water quality discipline. Potential changes to COPC concentrations in soil and vegetation were estimated from predicted aerial deposition rates using the deposition model presented in US EPA (1999, 2005); refer to Appendix C and D.

4.3.2.2 Simulation of Bioavailability and Metal Uptake

Estimates of bioavailability were used in exposure calculations, and fall under three main categories:

- bioconcentration (BCF) and bioaccumulation (BAF) factors;
- absorption factors (AF); and,
- bio-transfer and bio-uptake factors (BTF).

Bioaccumulation factors or bioconcentration factors represent the transfer of a COPC from a physical medium (e.g., soil, water) to plant or animal tissue via all relevant pathways. A bioaccumulation factor is represented as the equilibrium or steady-state ratio between an exposure medium and the organism tissue. Bioaccumulation factors account for all potential exposure routes (i.e., dermal, root absorption, respiratory, dietary).

Absorption in animals can be defined as the process by which substances enter the bloodstream. Depuration processes through which the body breaks down and excretes substances act concurrently with the absorption processes. Therefore, net absorption of a substance must account for depuration processes. Measuring net absorption is challenging, and few toxicological studies undertake this task. Furthermore, often the most soluble and most bioavailable (or absorptive) form of the chemical is used in the available toxicity studies (i.e., soluble salts of metals, such as chlorides, are typically used as the exposure substance). Thus, a common and conservative risk assessment approach is to assume complete absorption (i.e., absorption factor = 1.0) and was adopted in the wildlife health risk assessment.

Table 4.3-4 Model Assumptions for Concentrations of Constituents of Potential Concern in Source Media and Fish

Soil	Water	Sediment	Fish
COPC Screening Predicted from maximum of baseline soil concentrations (pooled for all locations sampled in the ESA)[(a)] and predicted **case-specific** incremental increase from air deposition. **Exposure Modelling** Predicted from 95% UCLM baseline soil concentrations (pooled for all locations sampled in the ESA)[(a)b)] and predicted **case-specific** incremental increase from air deposition.	**COPC Screening** Median baseline water concentrations (to serve as Base Case) and the maximum predicted depth-averaged Application Case surface water concentrations for LDS, LDG East and LDG West (under ice and open water scenarios) were used in the food chain model. **COPC Exposure Modelling** Same as COPC screening.	**COPC Screening** No screening conducted because concentrations of substances are not expected to change as a result of the Project. **Exposure Modelling** 95% UCLM of baseline, measured concentrations[(b)(c)]	**COPC Screening** Predicted using site-specific BAFs and case-specific water concentrations **Exposure Modelling** Predicted using site-specific BAFs[(d)] and case-specific water concentrations

a) Soil concentrations are predicted for all cases, including the Base Case.

b) Where the 95% UCLM could not be estimated, the 90th percentile or maximum was used.

c) Measured sediment concentrations are available for several waterbodies in the area such as LDS, Duchess Lake, Lake Af1, Lake C1, Lake E1, Paul Lake, Station Ab-S1, and several sub-basin streams from the aforementioned water bodies.

d) Site-specific bioaccumulation factors were applied, where possible, using regional collections of paired water and fish tissue monitoring data.

COPC = constituent of potential concern; % = percent; ESA = effects study area; UCLM = upper confidence limit of the mean; LDS = Lac du Sauvage; LDG = Lac de Gras.

Bio-transfer factors, media-to-organism BAFs, or media-to-organism uptake relationships were used to estimate the concentration of a COPC in tissues resulting from exposure to the COPC in the environment. Bio-transfer factors were used to convert the estimated dietary intake of a COPC by a species into a concentration of the COPC in tissue. The estimated dietary intake was combined with chemical-specific bio-transfer factors to estimate COPC concentrations. Mammalian bio-transfer factors were available from US EPA guidance.

4.3.2.3 Estimation of COPC Concentrations in Food Items

The details of COPC concentration modelling for food items (excluding fish, which is summarized in Table 4.3-4), including selected parameters, equations, and reference citations, are provided in Appendix D. A brief overview of the prediction approach is provided below:

- **Aquatic plants –** Plant tissue concentrations were predicted from case-specific water concentration and literature BAFs, based on available US EPA guidance.
- **Aquatic invertebrates –** Invertebrate tissue concentrations were predicted from case-specific water concentration and literature BAFs, based on available US EPA guidance and DeForest et al. (2007).
- **Terrestrial plants –** Site-specific BAFs were applied, where possible, using regional collections of paired soil and plant tissue monitoring data. Plant types included grasses, willow/birch, berries and lichen. Plant tissue concentrations were predicted from the 95% upper confidence limit on the mean baseline vegetation concentrations combined with the incremental case-specific increase due to root uptake and deposition on plant surfaces.
- **Small Mammals –** Accumulation equations from US EPA Ecological Soil Screening Level (US EPA (2007; Attachment 4-1) and Sample et al. (1998) were applied. Small mammal tissue concentrations were predicted from case-specific soil concentrations and the accumulation equations.
- **Caribou –** A BTF approach with parameters obtained from the Risk Assessment Information System (RAIS 2014) or US EPA (2005) was used. COPC concentrations in caribou meat were predicted from the case-specific COPC dose, and the BAF. For the wildlife health assessment, the case-specific dose was based on the worst-case location (MPOI). For the human health assessment, the case-specific dose was the highest of the three receptor locations evaluated.

4.3.2.4 Receptor Characteristics

The characteristics of the wildlife VCs considered in the wildlife risk assessment were obtained from the *Wildlife Exposure Factors Handbook* (US EPA 1993), in terms of ingestion rates, dietary components, and COPC transfer rates through trophic levels. Other literature sources were used to supplement this reference as necessary including those provided in Table D-4 and in Appendix D. Further details on the receptor-specific parameters and equations used in the food web model, including food and water ingestion rates, body weights, dietary preferences, and bioaccumulation/transfer factors used to estimate COPC concentrations in dietary items are provided in Appendix D.

4.3.3 Toxicity Assessment

The toxicity assessment provides the basis for evaluating what is an acceptable exposure and what level of exposure may adversely affect the health of wildlife. Toxicity assessment involves determining the amount of a chemical a wildlife receptor may take into the body through all applicable exposure pathways without it affecting their health; this parameter is called a TRV.

A stepwise procedure was used to identify wildlife TRVs. Where available, the United States Environmental Protection Agency (US EPA 2010) Eco-SSLs were selected for each COPC. Eco-SSLs represent a conservatively-based, systematic, and rigorous assessment of wildlife toxicity information. Where Eco-SSLs were unavailable, a literature review was conducted to identify candidate TRVs, beginning with the Oak Ridge National Laboratory Toxicological Benchmarks for Wildlife (Sample et al. 1996).

The wildlife health analysis was conducted using two sets of TRVs, reflecting very high (i.e., lower-TRVs) and moderately high (i.e., upper-TRVs) levels of protection in the effects assessment:

- Lower-TRVs were based on dietary concentrations or intake rates associated with no-observed-adverse-effect levels (NOAELs)[5] to test organisms (i.e., referred to henceforth as lower-TRVs). Although use of NOAELs has been discouraged in recent risk assessment guidance, the Eco-SSLs (which apply the geometric mean of NOAELs as the starting point for TRV derivations) were retained due to the high volume of toxicological data evaluated and the degree of rigour in the data quality screening. Eco-SSLs are “derived to be protective of the conservative end of the exposure and effects species distribution, and are intended to be applied at the screening stage of an ecological risk assessment” (US EPA 2007). Other lower-TRVs derived from sources other than Eco-SSLs, are similarly conservative. All such screening ecotoxicity values are derived to avoid underestimating risk, but are not intended to identify risk levels warranting management actions. Thus, predicted exposure which is below these lower-TRVs provides a strong indication that adverse effects on wildlife health are highly unlikely.
- Upper-TRVs were derived based on the relevant lowest observed adverse effect levels (LOAELs). They provide a more realistic assessment of the potential for adverse effects on wildlife receptors. However, as the upper-TRVs based on LOAELs represent the most sensitive documented relevant endpoints, they should not be interpreted as thresholds for the actual study populations or receptors, particularly where the surrogate species is dissimilar to the site-specific receptor of concern.

For common receptors, focus was placed on the results generated with the upper-TRVs, whereas for listed species, focus was placed on the results generated with the lower-TRVs.

Appendix F describes the toxicity studies and rationales for the TRVs selected for mammalian and avian receptors.

[5] When data are expressed as a concentration in food, the term no-observed-adverse-effect level (NOAEL) may be replaced with no-observed-adverse-effect concentration (NOAEC). The term NOAEL (or LOAEL) applies to both concentration and dose-based values.

4.3.4 Risk Characterization

Risk Characterization involves integration of the Exposure Assessment and Toxicity Assessment results to estimate potential risk to wildlife. For the wildlife health risk assessment, the primary decision criterion for Risk Characterization involved hazard quotients (HQs).

4.3.4.1 Hazard Quotients

Hazard quotients (HQ) for the Base and Application Cases were calculated as the ratio of the predicted exposure to TRVs as shown in the equation below.

$$HQ = \frac{EDI}{TRV}$$

Where:

EDI = estimated daily intake (mg/kg body weight/day);

TRV = toxicity reference value (mg/kg body weight/day).

An HQ greater than 1.0 indicates that there is a potential for adverse effects on wildlife health whereas HQs less than, or equal to, 1.0 indicate a negligible potential for adverse effects. However, HQ values greater than 1.0 do not necessarily indicate that adverse health effects on individuals or populations will actually occur due to the conservatism employed in their estimation (e.g., assuming that wildlife forage in restricted areas close to the Project boundary). Rather, the ecological significance of an HQ exceeding 1.0 must be assessed through evaluation of the technical assumptions and uncertainties underlying the risk analysis.

Quantitative risk characterization considered two overall measures of risk, which consisted of the following:

- The percentage (%) incremental increase in the HQ from the Base Case to the Application Case.
- The absolute magnitude of the HQs developed for each assessment case/scenario.

In practice, HQs are semi-quantitative predictors of risk that provide an ordinal estimate of risk (e.g., negligible, low, moderate, or high). However, the magnitudes of HQs are not linearly proportional to the magnitude of “risk.” Although a very large HQ may indicate a greater potential for harm relative to an HQ slightly greater than 1.0, it is not true that minor changes in the HQ provide a meaningful differentiation in actual risk (Ritter et al. 2002).

It is common for HQs to exceed 1.0 under existing conditions for multiple combinations of receptor and COPCs, as these HQs are based on highly conservative assumptions. For example, the bioavailability of total metals in the environment is assumed to be similar to the soluble salts used in some toxicity tests, even though total metals data includes both soluble and particulate forms of a COPC. Where HQs are greater than 1.0 under both existing and future conditions, but are of similar magnitude, it is presumed that one or more of the following conditions may apply:

- The receptor species is well-adapted to the COPC exposure.
- The receptor species has low sensitivity to the COPC relative to test organisms.
- The assumptions of exposure and effects assessments are highly conservative, leading to a potential overestimate of risk.

4.3.4.2 Uncertainty

In wildlife risk assessments, the largest uncertainties are associated with models and extrapolations used to estimate exposure, bioavailability, and toxicity of substances of resident wildlife. In the absence of highly detailed field studies and site-specific measurements (which can be destructive to the individuals and populations), such models are necessary. However, it is also necessary to place the conservatism and uncertainty of these models in context such that the numerical output of the models is properly interpreted.

When information is uncertain, it is standard practice in a risk assessment to make assumptions that are biased towards safety (i.e., conservative assumptions). The purpose of using conservative assumptions is to maximize the potential that risks are not underestimated for the “maximally exposed wildlife receptor.” Thus, there is high confidence in “negligible risk” conclusions when predicted exposure to COPCs does not exceed threshold values (i.e., does not exceed a hazard quotient of 1.0). The influence of these conservative assumptions on prediction confidence is discussed on Section 6.

In ecological risk assessment, narrative descriptions of risk are often subjective, and their definition depends on the level of conservatism and uncertainty in the risk analysis. In most cases, they provide an indication of the level of concern associated with a given HQ result, and they often integrate the probability and magnitude of potential risk in a single narrative indicator. Given the need to apply conservative assumptions in predictive risk assessments, narrative conclusions of “low” or “moderate” risk are rarely synonymous with an expected future condition of adverse effects that are low or moderate in magnitude. Rather, they indicate priorities for follow-up studies to refine risk assessment conclusions and possible follow-up and monitoring to confirm or refute risk conclusions.

4.3.4.3 Assessment of Individuals versus Populations

Although ecological risk assessments commonly focus on effects on populations, much confusion exists regarding the definition of the term population. The term "assessment population" has been defined as the component of the biological population or meta-population that is directly exposed to the stressors of potential concern (Barnthouse et al. 2007). This operational definition reflects public perspective on protection goals, in that the threshold of concern for charismatic species may be lower than the biological threshold of the minimum viable population. As the perceived value or vulnerability of a species increases, the tolerance for loss of individual organisms decreases.

Ecological risk assessment guidance (e.g., US EPA 1998) typically recommends that risk analysis focus at the population-level with respect to survival, growth, and reproduction. Healthy populations (i.e., populations whose individuals can survive, grow, and reproduce) are considered resilient to low-level disturbance and can withstand some effects on individuals within the population as long as the spatial and temporal scales and magnitude of risk do not push the population beyond its viability threshold. However, for species identified as being of special concern, sensitive, threatened, at risk or endangered, it is typically recommended that the level of protection focuses on individuals within a population, since the vulnerable status of the species already indicates concern for populations as a whole, and effects on individuals could exacerbate existing population stress.

The protection goal for receptors with designated species focused on the health of individuals, whereas the protection goal for receptors that are considered secure (or with no designated species) focused on the health of populations and not individuals.

In typical ecological risk assessment practice, exposure is estimated for individuals, and it is not always feasible to distinguish population effects from individual effects when establishing TRVs. For this risk assessment, measurement endpoints for protection of individuals were applied for vulnerable and secure receptors. The higher level of protection for receptors with listed species was considered in the TRVs applied and in interpretation of the hazard quotient results.

5 RESIDUAL EFFECTS ANALYSIS

5.1 Human Health Effects – Air Quality Assessment

5.1.1 Summary of Assessment Cases for Air Quality Modelling

The air quality assessment in the Jay Project modelled Base Case, Construction Case, and Application Case. The assessment cases were defined as the following:

The Base Case represents a range of conditions over time within the effects study area (ESA) before application of the Project. The Base Case describes the existing environment prior to the application of the Project, to provide an understanding of the current conditions that may be influenced by the Project. The Base Case (year 2015) includes the cumulative effects from all previous and existing developments and activities that are planned and approved (e.g., Lynx Project). Current effects from ongoing projects that are approved (e.g., mining and reclamation at Ekati and Diavik mines) are included in the Base Case. Previous and existing exploration activities and portages associated with winter roads are also included in the Base Case.

The Construction Case represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project's construction activities. Because the construction phase is expected to last up to three years, the effects of the Construction Case are expected to be temporary relative to the effects of the Application Case. The Construction Case in the air quality assessment is based on the Base Case emission profile (year 2015) plus the maximum emission profile for the Project's construction activities.

The Application Case (year 2022) represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project. The Application Case in the air quality assessment is based on the Base Case emission profile but with the emissions associated with mining activities at Base Case Ekati Mine replaced by the emissions associated with the Project's mining activities.

In order to account for the contribution of Project operation and Project construction in air quality, a Project Contribution (Operations) and a Project Contribution (Construction) increment was assessed.

The Project Contribution (Construction) represents predictions of the contribution of Project construction without considering the cumulative effects from baseline conditions (model year 2002). The Project Contribution (Construction) was modelled based on the maximum emission profile for the Project's construction activities.

The Project Contribution (Operations) scenario represents predictions of the contribution of Project operation without considering the cumulative effects from the existing conditions (Base Case). The Project Contribution (Operations) concentrations were modelled by subtracting model predicted Base Case concentrations for each hour in the modelling year and at each receptor location, from the Application Case concentrations. Then, the maximum Project Contribution (Operations) concentrations of each receptor were identified from the results of receptor location paired subtraction process. Negative values for the Project Contribution (Operations) indicate that the Project activities will result in decreases of predicted concentrations.

5.1.2 Acute Inhalation Assessment

5.1.2.1 Summary of Hazard Quotients

Hazard quotients (HQs) were calculated for parameters identified as COPCs in the 1-hour and 24-hour assessment by comparing the concentration predicted for each location with toxicity benchmarks for the Base Case, Construction Case, and Application Case (operations phase). HQs were also calculated for the Project contribution for each case (Project contribution from construction only or operations only), to show what contribution to risk estimates the Project alone is predicted to have for each case (i.e., without background incorporated).

1-Hour Assessment

Aluminum, barium, beryllium, cadmium, chromium, iron, manganese, and nickel were identified as COPCs for the 1-hour assessment. The HQ values calculated for the Base Case, Construction Case, and Application Case are presented in Tables 5.1-1 to 5.1-9.

Table 5.1-1 Hazard Quotients for Maximum 1-Hour Predicted Aluminum Concentrations

Receptor Location	Hazard Quotient - Aluminum					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.0027	0.0056	0.0037	0.0027	0.0052	0.0039
Diavik Camp	0.33	0.33	0.060	0.33	0.33	0.042
Diavik TK Camp	0.17	0.19	0.074	0.17	0.13	0.13
Ekati Camp/Admin	0.76	0.76	0.028	0.76	0.44	0.051
Lac de Gras Winter Road Rest Stop	0.035	0.051	0.034	0.035	0.055	0.055
LDG Hunting Camp	0.09	0.091	0.047	0.09	0.09	0.088
Misery Camp	**1.7**	**1.7**	**1.4**	**1.7**	0.54	0.54
Pellatt Lake Cabin	0.0032	0.010	0.0070	0.0032	0.010	0.0063
Salmita Airstrip	0.0025	0.0060	0.0037	0.0025	0.0055	0.0032
Treeline Lodge	0.0024	0.0061	0.0037	0.0024	0.0056	0.0032
MPOI	**11**	**21**	**21**	**11**	**38**	**38**

Note: **Bold and underlined** values exceed the target hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-2 Hazard Quotients for Maximum 1-Hour Predicted Barium Concentrations

Receptor Location	Hazard Quotient - Barium					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.000099	0.00018	0.00012	0.000099	0.00018	0.00013
Diavik Camp	0.021	0.021	0.0020	0.021	0.021	0.0014
Diavik TK Camp	0.0055	0.0063	0.0024	0.0055	0.0042	0.0042
Ekati Camp/Admin	0.033	0.033	0.00090	0.033	0.0203	0.0017
Lac de Gras Winter Road Rest Stop	0.0011	0.0017	0.0011	0.0011	0.0018	0.0018
LDG Hunting Camp	0.0028	0.0030	0.0015	0.0028	0.0029	0.0029
Misery Camp	0.054	0.055	0.045	0.054	0.018	0.018
Pellatt Lake Cabin	0.00012	0.00035	0.00023	0.00012	0.00033	0.00021
Salmita Airstrip	0.000090	0.00020	0.00012	0.000090	0.00019	0.00011
Treeline Lodge	0.000080	0.00020	0.00012	0.000080	0.00019	0.00011
MPOI	0.37	0.68	0.68	0.37	<u>**1.2**</u>	<u>**1.2**</u>

Note: <u>**Bold and underlined**</u> values exceed the target hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-3 Hazard Quotients for Maximum 1-Hour Predicted Beryllium Concentrations

Receptor Location	Hazard Quotient – Beryllium					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.00059	0.00060	0.00010	0.00059	0.00059	0.00011
Diavik Camp	0.21	0.21	0.0017	0.21	0.21	0.0012
Diavik TK Camp	0.026	0.026	0.0021	0.026	0.026	0.0036
Ekati Camp/Admin	0.026	0.026	0.00078	0.026	0.013	0.0015
Lac de Gras Winter Road Rest Stop	0.013	0.013	0.0010	0.013	0.012	0.0015
LDG Hunting Camp	0.0093	0.0093	0.0013	0.0093	0.0093	0.0025
Misery Camp	0.054	0.054	0.039	0.054	0.018	0.015
Pellatt Lake Cabin	0.00077	0.00077	0.00020	0.00077	0.00077	0.00018
Salmita Airstrip	0.0011	0.0011	0.00010	0.0011	0.0011	0.000090
Treeline Lodge	0.0011	0.0011	0.00011	0.0011	0.0011	0.000091
MPOI	0.32	0.59	0.59	0.32	**<u>1.1</u>**	**<u>1.1</u>**

Note: **<u>Bold and underlined</u>** values exceed the target hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

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Table 5.1-4 Hazard Quotients for Maximum 1-Hour Predicted Cadmium Concentrations

Receptor Location	Hazard Quotient - Cadmium					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.0023	0.0026	0.00024	0.0023	0.0029	0.00056
Diavik Camp	0.60	0.60	0.0037	0.60	0.60	0.0083
Diavik TK Camp	0.055	0.056	0.0059	0.055	0.056	0.015
Ekati Camp/Admin	0.060	0.060	0.0013	0.060	0.060	0.0081
Lac de Gras Winter Road Rest Stop	0.027	0.027	0.0030	0.027	0.027	0.0059
LDG Hunting Camp	0.017	0.017	0.0073	0.017	0.018	0.017
Misery Camp	0.029	0.031	0.030	0.029	0.079	0.079
Pellatt Lake Cabin	0.0019	0.0022	0.00054	0.0019	0.0026	0.0013
Salmita Airstrip	0.0035	0.0038	0.00032	0.0035	0.0041	0.00081
Treeline Lodge	0.0036	0.0039	0.00032	0.0036	0.0043	0.00078
MPOI	0.59	0.59	0.40	0.59	**1.2**	**1.2**

Note: **Bold and underlined** values exceed the target hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-5 Hazard Quotients for Maximum 1-Hour Predicted Chromium (VI) Concentrations

Receptor Location	Hazard Quotient – Chromium (VI)					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.0019	0.0029	0.0019	0.0019	0.0030	0.0021
Diavik Camp	0.65	0.65	0.031	0.65	0.65	0.022
Diavik TK Camp	0.09	0.098	0.038	0.09	0.066	0.066
Ekati Camp/Admin	0.71	0.71	0.014	0.71	0.64	0.027
Lac de Gras Winter Road Rest Stop	0.031	0.031	0.018	0.031	0.031	0.029
LDG Hunting Camp	0.044	0.047	0.024	0.044	0.046	0.046
Misery Camp	0.85	0.85	0.71	0.85	0.29	0.29
Pellatt Lake Cabin	0.0022	0.0059	0.0036	0.0022	0.0057	0.0034
Salmita Airstrip	0.0018	0.0034	0.0019	0.0018	0.0031	0.0018
Treeline Lodge	0.0020	0.0033	0.0019	0.0020	0.0032	0.0018
MPOI	**5.8**	**11**	**11**	**5.8**	**19**	**19**

Note: **Bold and underlined** values exceed the target hazard quotient of 1.0.
The predicted chromium concentrations were assumed to be entirely in the hexavalent form.
MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-6 Hazard Quotients for Maximum 1-Hour Predicted Chromium (III) Concentrations

Receptor Location	Hazard Quotient – Chromium (III)					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.000053	0.000081	0.000052	0.000053	0.000082	0.000059
Diavik Camp	0.018	0.018	0.00085	0.018	0.018	0.00062
Diavik TK Camp	0.0024	0.0027	0.0011	0.0024	0.0018	0.0018
Ekati Camp/Admin	0.020	0.020	0.00039	0.020	0.018	0.00074
Lac de Gras Winter Road Rest Stop	0.00086	0.00086	0.00049	0.00086	0.00086	0.00079
LDG Hunting Camp	0.0012	0.0013	0.00068	0.0012	0.0013	0.0013
Misery Camp	0.024	0.024	0.020	0.024	0.0080	0.0080
Pellatt Lake Cabin	0.000062	0.00016	0.00010	0.000062	0.00016	0.000096
Salmita Airstrip	0.000051	0.000094	0.000053	0.000051	0.000087	0.000049
Treeline Lodge	0.000056	0.000092	0.000053	0.000056	0.000088	0.000049
MPOI	0.16	0.30	0.30	0.16	0.54	0.54

Note: The predicted chromium concentrations were assumed to be entirely in the trivalent form.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-7 Hazard Quotients for Maximum 1-Hour Predicted Iron Concentrations

Receptor Location	Hazard Quotient - Iron					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.0015	0.0027	0.0017	0.0015	0.0026	0.0019
Diavik Camp	0.32	0.32	0.028	0.32	0.32	0.020
Diavik TK Camp	0.080	0.091	0.035	0.080	0.061	0.061
Ekati Camp/Admin	0.49	0.49	0.013	0.49	0.30	0.024
Lac de Gras Winter Road Rest Stop	0.016	0.024	0.016	0.016	0.026	0.026
LDG Hunting Camp	0.041	0.043	0.022	0.041	0.042	0.042
Misery Camp	0.79	0.79	0.66	0.79	0.26	0.26
Pellatt Lake Cabin	0.0017	0.0050	0.0033	0.0017	0.0048	0.0031
Salmita Airstrip	0.0013	0.0029	0.0017	0.0013	0.0027	0.0016
Treeline Lodge	0.0012	0.0029	0.0018	0.0012	0.0027	0.0016
MPOI	**5.4**	**9.9**	**9.9**	**5.4**	**18**	**18**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-8 Hazard Quotients for Maximum 1-Hour Predicted Manganese Concentrations

Receptor Location	Hazard Quotient - Manganese					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.00012	0.00020	0.00013	0.00012	0.00020	0.00015
Diavik Camp	0.031	0.031	0.0022	0.031	0.031	0.0016
Diavik TK Camp	0.0061	0.0070	0.0027	0.0061	0.0047	0.0047
Ekati Camp/Admin	0.041	0.041	0.0010	0.041	0.029	0.0019
Lac de Gras Winter Road Rest Stop	0.0016	0.0019	0.0012	0.0016	0.0020	0.0020
LDG Hunting Camp	0.0031	0.0033	0.0017	0.0031	0.0033	0.0033
Misery Camp	0.060	0.061	0.050	0.060	0.020	0.020
Pellatt Lake Cabin	0.00014	0.00040	0.00026	0.00014	0.00038	0.00024
Salmita Airstrip	0.00011	0.00023	0.00013	0.00011	0.00021	0.00012
Treeline Lodge	0.00012	0.00023	0.00014	0.00012	0.00022	0.00012
MPOI	0.41	0.76	0.76	0.41	**1.4**	**1.4**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

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Table 5.1-9 Hazard Quotients for Maximum 1-Hour Predicted Nickel Concentrations

Receptor Location	Hazard Quotient - Nickel					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.00023	0.00023	0.000077	0.00023	0.00023	0.00011
Diavik Camp	0.20	0.20	0.0012	0.20	0.20	0.0012
Diavik TK Camp	0.020	0.020	0.0015	0.020	0.020	0.0030
Ekati Camp/Admin	0.24	0.24	0.00055	0.24	0.23	0.0011
Lac de Gras Winter Road Rest Stop	0.0094	0.0094	0.00068	0.0094	0.0094	0.0013
LDG Hunting Camp	0.0075	0.0075	0.00094	0.0075	0.0075	0.0018
Misery Camp	0.036	0.036	0.028	0.036	0.023	0.022
Pellatt Lake Cabin	0.00031	0.00038	0.00014	0.00031	0.00041	0.00018
Salmita Airstrip	0.00040	0.00040	0.00008	0.00040	0.00040	0.00011
Treeline Lodge	0.00032	0.00032	0.00008	0.00032	0.00032	0.00010
MPOI	0.32	0.42	0.42	0.32	**1.8**	**1.8**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

For the Construction Case, 1-hour HQs were greater than 1.0 at the MPOI for aluminum, chromium, and iron, and also at the Misery Camp for aluminum. For the Application Case, 1-hour HQs were greater than 1.0 at the MPOI for aluminum, barium, beryllium, cadmium, chromium, iron, manganese, and nickel. Further analysis of these parameters is provided in Section 5.1.1.2.

24-Hour Assessment

The HQ values calculated for maximum 24-hour exposure to nitrogen dioxide, aluminum, cadmium, chromium, iron, manganese, and nickel for the Base Case, Construction Case, and Application Case are presented in Tables 5.1-10 to 5.1-17. The HQ values for maximum 24-hour exposure to the sum of cadmium, chromium, and nickel, which have the same endpoint of respiratory effects, are provided in Table 5.1-18.

Table 5.1-10 Hazard Quotients for Maximum 24-Hour Predicted Nitrogen Dioxide Concentrations

Receptor Location	Hazard Quotient – Nitrogen Dioxide					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.019	0.019	0.0011	0.019	0.022	0.0036
Diavik Camp	0.48	0.48	0.016	0.48	0.48	0.054
Diavik TK Camp	0.32	0.32	0.025	0.32	0.31	0.079
Ekati Camp/Admin	0.30	0.30	0.0086	0.30	0.38	0.28
Lac de Gras Winter Road Rest Stop	0.25	0.25	0.014	0.25	0.24	0.046
LDG Hunting Camp	0.11	0.12	0.11	0.11	0.29	0.29
Misery Camp	0.25	0.30	0.13	0.25	0.37	0.31
Pellatt Lake Cabin	0.020	0.021	0.0028	0.020	0.025	0.0092
Salmita Airstrip	0.058	0.060	0.0019	0.058	0.064	0.0064
Treeline Lodge	0.054	0.056	0.0018	0.054	0.060	0.0060
MPOI	0.70	0.73	0.73	0.70	**1.6**	**1.6**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

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Table 5.1-11 Hazard Quotients for Maximum 24-Hour Predicted Aluminum Concentrations

Receptor Location	Hazard Quotient – Aluminum					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.00015	0.00027	0.00016	0.00015	0.00026	0.00016
Diavik Camp	0.039	0.039	0.0041	0.039	0.039	0.0018
Diavik TK Camp	0.0043	0.0068	0.0045	0.0043	0.0068	0.0044
Ekati Camp/Admin	0.031	0.031	0.0010	0.031	0.018	0.0010
Lac de Gras Winter Road Rest Stop	0.0011	0.0033	0.0026	0.0011	0.0034	0.0028
LDG Hunting Camp	0.0023	0.0033	0.0033	0.0023	0.0045	0.0045
Misery Camp	0.072	0.082	0.044	0.072	0.033	0.032
Pellatt Lake Cabin	0.00015	0.00039	0.00024	0.00015	0.00035	0.00020
Salmita Airstrip	0.00016	0.00021	0.00012	0.00016	0.00018	0.000089
Treeline Lodge	0.00014	0.00022	0.00012	0.00014	0.00019	0.00010
MPOI	0.58	**<u>1.6</u>**	**<u>1.6</u>**	0.58	**<u>2.3</u>**	**<u>2.3</u>**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-12 Hazard Quotients for Maximum 24-Hour Predicted Cadmium Concentrations

Receptor Location	Hazard Quotient – Cadmium					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.0018	0.0019	0.00025	0.0018	0.0022	0.00062
Diavik Camp	0.36	0.36	0.0026	0.36	0.36	0.0071
Diavik TK Camp	0.085	0.085	0.0051	0.085	0.085	0.012
Ekati Camp/Admin	0.077	0.077	0.0015	0.077	0.083	0.011
Lac de Gras Winter Road Rest Stop	0.030	0.030	0.0031	0.030	0.030	0.0089
LDG Hunting Camp	0.0020	0.018	0.017	0.0020	0.030	0.028
Misery Camp	0.042	0.055	0.027	0.042	0.095	0.093
Pellatt Lake Cabin	0.0020	0.0023	0.00035	0.0020	0.0028	0.00085
Salmita Airstrip	0.0053	0.0057	0.00038	0.0053	0.0062	0.00092
Treeline Lodge	0.0049	0.0053	0.00037	0.0049	0.0058	0.00092
MPOI	0.56	0.79	0.79	0.56	**<u>1.9</u>**	**<u>1.9</u>**

Note: **<u>Bold and underlined</u>** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

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Table 5.1-13 Hazard Quotients for Maximum 24-Hour Predicted Chromium (VI) Concentrations

Receptor Location	Hazard Quotient – Chromium (VI)					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.00016	0.00023	0.00013	0.00016	0.00023	0.00013
Diavik Camp	0.096	0.096	0.0032	0.096	0.096	0.0015
Diavik TK Camp	0.0060	0.0060	0.0035	0.0060	0.0060	0.0037
Ekati Camp/Admin	0.076	0.076	0.00082	0.076	0.066	0.00089
Lac de Gras Winter Road Rest Stop	0.0019	0.0026	0.0020	0.0019	0.0028	0.0023
LDG Hunting Camp	0.00016	0.0026	0.0026	0.00016	0.0037	0.0037
Misery Camp	0.057	0.065	0.035	0.057	0.027	0.027
Pellatt Lake Cabin	0.00016	0.00035	0.00019	0.00016	0.00034	0.00017
Salmita Airstrip	0.00017	0.00019	0.000094	0.00017	0.00019	0.000077
Treeline Lodge	0.00015	0.00023	0.000094	0.00015	0.00020	0.000081
MPOI	0.45	**<u>1.3</u>**	**<u>1.3</u>**	0.45	**<u>1.8</u>**	**<u>1.8</u>**

Note: **<u>Bold and underlined</u>** values exceed a hazard quotient of 1.0.

The predicted chromium concentrations were assumed to be entirely in the hexavalent form.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-14 Hazard Quotients for Maximum 24-Hour Predicted Chromium (III) Concentrations

Receptor Location	Hazard Quotient – Chromium (III)					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.00013	0.00018	0.00010	0.00013	0.00018	0.00010
Diavik Camp	0.075	0.075	0.0025	0.075	0.075	0.0012
Diavik TK Camp	0.0047	0.0047	0.0028	0.0047	0.0047	0.0029
Ekati Camp/Admin	0.059	0.059	0.00064	0.059	0.0516	0.00069
Lac de Gras Winter Road Rest Stop	0.00146	0.0020	0.0016	0.00146	0.0022	0.0018
LDG Hunting Camp	0.00013	0.0020	0.0020	0.00013	0.0029	0.0029
Misery Camp	0.044	0.051	0.027	0.044	0.021	0.021
Pellatt Lake Cabin	0.00013	0.00028	0.00015	0.00013	0.00026	0.00014
Salmita Airstrip	0.00014	0.00015	0.000073	0.00014	0.00015	0.000060
Treeline Lodge	0.00012	0.00018	0.000073	0.00012	0.00016	0.000063
MPOI	0.35	0.99	1.0	0.35	**<u>1.4</u>**	**<u>1.4</u>**

Note: **<u>Bold and underlined</u>** values exceed a hazard quotient of 1.0.
The predicted chromium concentrations were assumed to be entirely in the trivalent form.
MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-15 Hazard Quotients for Maximum 24-Hour Predicted Iron Concentrations

Receptor Location	Hazard Quotient – Iron					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.0012	0.0020	0.0012	0.0012	0.0019	0.0011
Diavik Camp	0.52	0.52	0.029	0.52	0.52	0.013
Diavik TK Camp	0.031	0.049	0.032	0.031	0.049	0.032
Ekati Camp/Admin	0.37	0.37	0.0074	0.37	0.31	0.0075
Lac de Gras Winter Road Rest Stop	0.010	0.023	0.018	0.010	0.025	0.020
LDG Hunting Camp	0.0012	0.024	0.024	0.0012	0.032	0.032
Misery Camp	0.51	0.59	0.32	0.51	0.23	0.23
Pellatt Lake Cabin	0.0012	0.0029	0.0017	0.0012	0.0026	0.0015
Salmita Airstrip	0.0013	0.0016	0.00085	0.0013	0.0014	0.00066
Treeline Lodge	0.0011	0.0017	0.00085	0.0011	0.0015	0.00070
MPOI	**4.1**	**11**	**11**	**4.1**	**16**	**16**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-16 Hazard Quotients for Maximum 24-Hour Predicted Manganese Concentrations

Receptor Location	Hazard Quotient – Manganese					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.00081	0.00124	0.00072	0.00081	0.0012	0.00071
Diavik Camp	0.39	0.39	0.018	0.39	0.39	0.0083
Diavik TK Camp	0.026	0.030	0.020	0.026	0.030	0.020
Ekati Camp/Admin	0.29	0.29	0.0045	0.29	0.24	0.0048
Lac de Gras Winter Road Rest Stop	0.0083	0.014	0.011	0.0083	0.015	0.012
LDG Hunting Camp	0.00083	0.014	0.014	0.00083	0.020	0.020
Misery Camp	0.31	0.36	0.19	0.31	0.15	0.15
Pellatt Lake Cabin	0.0008	0.0019	0.0011	0.0008	0.0018	0.00092
Salmita Airstrip	0.00087	0.0010	0.00052	0.00087	0.00090	0.00041
Treeline Lodge	0.00074	0.0012	0.00052	0.00074	0.0010	0.00044
MPOI	**2.5**	**7.0**	**7.0**	**2.5**	**9.8**	**9.8**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

Table 5.1-17 Hazard Quotients for Maximum 24-Hour Predicted Nickel Concentrations

Receptor Location	Hazard Quotient - Nickel					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.00033	0.00035	0.000068	0.00033	0.00035	0.00010
Diavik Camp	0.32	0.32	0.0016	0.32	0.32	0.0017
Diavik TK Camp	0.020	0.020	0.0018	0.020	0.020	0.0026
Ekati Camp/Admin	0.31	0.31	0.00041	0.31	0.29	0.00068
Lac de Gras Winter Road Rest Stop	0.0062	0.0062	0.0010	0.0062	0.0061	0.0015
LDG Hunting Camp	0.00024	0.0035	0.0013	0.00024	0.0035	0.0024
Misery Camp	0.030	0.034	0.019	0.030	0.021	0.019
Pellatt Lake Cabin	0.00024	0.00029	0.00010	0.00024	0.00034	0.00013
Salmita Airstrip	0.00028	0.00030	0.000049	0.00028	0.00031	0.000066
Treeline Lodge	0.00023	0.00027	0.000049	0.00023	0.00028	0.000061
MPOI	0.23	0.63	0.63	0.23	**1.5**	**1.5**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

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Table 5.1-18 Sum of Hazard Quotients by Target Organ/Effect for Maximum 24-Hour Predicted Concentrations

Receptor Location	Hazard Quotient – Sum of Cadmium, Chromium and Nickel – Respiratory Effects					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	0.0023	0.0025	0.00045	0.0023	0.0027	0.00085
Diavik Camp	0.77	0.77	0.0074	0.77	0.77	0.010
Diavik TK Camp	0.11	0.11	0.010	0.11	0.11	0.019
Ekati Camp/Admin	0.46	0.46	0.0028	0.46	0.43	0.012
Lac de Gras Winter Road Rest Stop	0.038	0.039	0.0062	0.038	0.039	0.013
LDG Hunting Camp	0.0024	0.025	0.021	0.0024	0.037	0.034
Misery Camp	0.13	0.15	0.080	0.13	0.14	0.14
Pellatt Lake Cabin	0.0024	0.0030	0.00064	0.0024	0.0035	0.0012
Salmita Airstrip	0.0057	0.0062	0.00053	0.0057	0.0067	0.0011
Treeline Lodge	0.0053	0.0058	0.00051	0.0053	0.0063	0.0011
MPOI	**1.2**	**2.7**	**2.7**	**1.2**	**5.1**	**5.1**

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; TK = Traditional Knowledge.

For the Construction Case, 24-hour HQs were greater than 1.0 at the MPOI for aluminum, chromium, iron, and manganese. For the Application Case, 24-hour HQs were greater than 1.0 at the MPOI for nitrogen dioxide, aluminum, cadmium, chromium, iron, manganese, and nickel. Further analysis of these parameters is provided in Section 5.1.1.2.

5.1.2.2 Further Analyses of Parameters with Hazard Quotients Greater than One

For parameters and locations where HQ values were greater than 1.0 for the Construction Case or Application Case, the frequency of exceedance of the 1-hour and 24-hour maximum concentrations of each COPC over the course of a year was calculated to determine the magnitude of risk. The frequency of exceedances for COPCs with HQs greater than 1.0 is summarized in Tables 5.1-20 to 5.1-21 (1-hour) and Tables 5.1-22 to 5.1-23 (24-hour).

Results of the assessment of magnitude of risk for the acute air quality assessment (1-hour and 24-hour) are presented in Tables 5.1-24 to 5.1-39. For parameters that had the highest frequency of exceedances, contour maps showing the spatial distribution of concentrations above the threshold are provided for the Base Case, Construction Case, and Application Case in Maps I-1 to I-15 (Appendix I).

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Table 5.1-19 Predicted 1-Hour Concentrations and Frequency of Exceedances for the Construction Case

Parameter	1-Hour Threshold (µg/m³)	Base Case				Construction Case				Project Contribution (Construction Only)			
		Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)	Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)	Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)
Misery Camp													
Aluminum	20	**33**	4.6	0.53	30	33	5.8	1.5	38	**28**	2.2	0.54	2
	50				0				0				0
MPOI													
Aluminum	20	**226**	**45**	15	1524	**419**	**167**	**35**	3,346	**419**	**166**	**35**	3,343
	50				337				1,676				1,674
Barium	5	1.8	0.37	0.13	0	3.4	1.4	0.29	0	3.4	1.4	0.29	0
Beryllium	0.02	0.0064	0.0013	0.00044	0	0.012	0.0047	0.00099	0	0.012	0.0047	0.00099	0
Cadmium	0.1	0.059	0.012	0.0025	0	0.059	0.020	0.0048	0	0.040	0.014	0.0037	0
Chromium (VI)[a]	0.1	**0.58**	**0.11**	0.040	578	**1.1**	**0.43**	0.090	2,010	**1.1**	**0.42**	0.090	2,009
Chromium (III)[b]	3.6	0.58	0.11	0.040	0	1.1	0.43	0.090	0	1.1	0.42	0.090	0
Iron	10	**54**	**11**	3.7	505	**99**	**40**	8.3	1,879	**99**	**39**	8.3	1,878
Manganese	2	0.82	0.16	0.056	0	1.5	0.61	0.13	0	1.5	0.60	0.13	0
Nickel	0.33	0.11	0.015	0.0053	0	0.14	0.055	0.012	0	0.14	0.054	0.012	0

a) The entire predicted chromium concentrations were assumed to be in the hexavalent form.
b) The entire predicted chromium concentrations were assumed to be in the trivalent form.
Note: **Bold and underlined** values exceed the acute threshold.
MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); µg/m³ = micrograms per cubic metre.

Table 5.1-20 Predicted 1-Hour Concentrations and Frequency of Exceedances for the Application Case

Parameter	1-Hour Threshold (µg/m³)	Base Case				Application Case				Project Contribution (Operations Only)			
		Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)	Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)	Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)
Misery Camp													
Aluminum	20	**33**	4.6	0.53	30	11	1.4	0.25	0	11	1.2	0.094	0
	50				0				0				0
MPOI													
Aluminum	20	**226**	**45**	15	1524	**753**	**142**	**33**	3,436	**753**	**121**	**32**	3,409
	50				337				1,416				1,347
Barium	5	1.8	0.37	0.13	0	**6.1**	1.2	0.27	2	**6.1**	0.99	0.26	2
Beryllium	0.02	0.0064	0.0013	0.00044	0	**0.021**	0.0040	0.00093	1	**0.021**	0.0034	0.00091	1
Cadmium	0.1	0.059	0.012	0.0025	0	**0.12**	0.035	0.085	3	**0.12**	0.032	0.0091	2
Chromium (VI)[a]	0.1	**0.58**	**0.11**	0.040	578	**1.9**	**0.36**	0.085	1,892	**1.9**	**0.31**	0.084	1,849
Chromium (III)[b]	3.6	0.58	0.11	0.040	0	1.9	0.36	0.085	0	1.9	0.31	0.084	0
Iron	10	**54**	**11**	3.7	505	**179**	**34**	7.8	1,721	**179**	**29**	7.7	1,667
Manganese	2	0.82	0.16	0.056	0	**2.7**	0.52	0.12	9	**2.7**	0.44	0.12	3
Nickel	0.33	0.11	0.015	0.0053	0	**0.60**	0.10	0.038	24	**0.60**	0.10	0.038	24

a) The entire predicted chromium concentrations were assumed to be in the hexavalent form.
b) The entire predicted chromium concentrations were assumed to be in the trivalent form.
Note: **Bold and underlined** values exceed the acute threshold.
MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site).

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Table 5.1-21 Predicted 24-Hour Concentrations and Frequency of Exceedances at the Maximum Off-Site Location (MPOI) for the Construction Case

Parameter	24-Hour Threshold (µg/m³)	Base Case				Construction Case				Project Contribution (Construction Only)			
		Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)	Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)	Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)
Nitrogen dioxide	200	140	72	44	0	147	83	58	0	146	83	57	0
Aluminum	120	70	40	17	0	**193**	**134**	43	23	**193**	**134**	43	23
Cadmium	0.03	0.017	0.0074	0.0032	0	0.024	0.013	0.0064	0	0.024	0.011	0.0045	0
Chromium VI [a]	0.39	0.18	0.10	0.045	0	**0.49**	0.34	0.11	9	**0.49**	0.34	0.11	9
Chromium III [b]	0.5	0.18	0.10	0.045	0	0.49	0.34	0.11	0	0.49	0.34	0.11	0
Iron	4	**17**	**9.4**	**4.1**	95	**46**	**32**	**10**	194	**46**	**32**	**10**	194
Manganese	0.1	**0.25**	**0.14**	0.063	43	**0.70**	**0.49**	**0.16**	135	**0.70**	**0.49**	**0.16**	135
Nickel	0.1	0.023	0.013	0.0058	0	0.063	0.044	0.014	0	0.063	0.044	0.014	0

a) The entire predicted chromium concentrations were assumed to be in the hexavalent form.
b) The entire predicted chromium concentrations were assumed to be in the trivalent form.
Note: **Bold and underlined** values exceed the acute threshold.
MPOI= maximum point of impingement (i.e., maximum concentration outside the mine site); µg/m³ = micrograms per cubic metre.

Table 5.1-22 Predicted 24-Hour Concentrations and Frequency of Exceedance at the Maximum Off-Site Location (MPOI) for the Application Case

Parameter	24-Hour Threshold (µg/m³)	Base Case				Application Case				Project Contribution (Operations Only)			
		Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)	Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)	Maximum Concentration (µg/m³)	95th Percentile Concentration (µg/m³)	75th Percentile Concentration (µg/m³)	Frequency of Exceedance (Number of Exceedances in a Year)
Nitrogen dioxide	200	140	72	44	0	**321**	126	82	1	**320**	124	82	1
Aluminum	120	70	40	17	0	**271**	115	40	17	**270**	99	40	10
Cadmium	0.03	0.017	0.0074	0.0032	0	**0.057**	0.026	0.011	10	**0.057**	0.019	0.0080	6
Chromium (VI)[a]	0.39	0.18	0.10	0.045	0	**0.69**	0.30	0.11	8	**0.69**	0.25	0.11	4
Chromium (III)[b]	0.5	0.18	0.10	0.045	0	**0.69**	0.30	0.11	2	**0.69**	0.25	0.11	2
Iron	4	**17**	**9.4**	**4.1**	95	**64**	**27**	**9.6**	197	**64**	**23**	**9.6**	194
Manganese	0.1	**0.25**	**0.14**	0.063	43	**0.98**	**0.42**	**0.15**	139	**0.98**	**0.36**	**0.15**	138
Nickel	0.1	0.023	0.013	0.0058	0	**0.15**	0.071	0.039	5	**0.15**	0.061	0.036	2

a) The entire predicted chromium concentrations were assumed to be in the hexavalent form.
b) The entire predicted chromium concentrations were assumed to be in the trivalent form.
Note: **Bold and underlined** values exceed the acute threshold.
MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); µg/m³ = micrograms per cubic metre.

Table 5.1-23 Further Analysis of Aluminum and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 1-hour concentration at the MPOI (419 µg/m^3) exceeded the acute exposure limit of 20 µg/m^3, primarily a result of the Project contribution. The 75th (35 µg/m^3) and 95th (167 µg/m^3) percentile concentrations also exceeded the acute exposure limit at the MPOI. At the Misery Camp, the maximum concentration (33 µg/m^3) exceeded the acute exposure limit, while the 75th and 95th percentile concentrations did not. • **Application Case:** The maximum predicted 1-hour concentration at the MPOI (753 µg/m^3) exceeded the acute exposure limit of 20 µg/m^3, primarily a result of the Project contribution. The 75th (33 µg/m^3) and 95th (142 µg/m^3) percentile concentrations also exceeded the acute exposure limit at the MPOI. At the Misery Camp, the maximum concentration was less than the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 11 and increased to 21 for the Construction Case and 38 for the Application Case. The Project Contribution (Construction Case) HQ was 21 and the Project Contribution (Operations Only) HQ was 38 at the MPOI. • At the Misery Camp, the HQ for the Base Case and Construction Case was 1.7 and the HQ for the Application Case was 0.54. The Project Contribution (Construction Case) HQ was 1.4 and the Project Contribution (Operations Only) HQ was 0.54 at the Misery Camp.
Frequency of exceedances	• There were 3,346 hourly exceedances of the threshold at the MPOI for the Construction Case, based on a year of modelling. • There were 3,436 hourly exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling. • At the Misery Camp, there were 30 exceedances of the threshold for the Base Case, 38 exceedances for the Construction Case, and no exceedances for the Application Case.
Conservatism and uncertainty in air predictions	• The primary emission source of aluminum is road dust. Other emission sources include bulldozing and crushing, screening, and conveying of ore and waste rock. The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 1-hour threshold for aluminum	• The TCEQ provides a threshold of 20 µg/m^3 for aluminum soluble salts and 50 µg/m^3 for aluminum chloride. Exceedances of both thresholds were identified in this assessment. The species that the emitted aluminum will form is not known. The TCEQ thresholds are based on a health endpoint; however, the agency does not have supporting information on the basis of the derivation of these thresholds. Due to the lack of supporting documentation, the conservatism incorporated into the derivation of the acute threshold is unknown.

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Table 5.1-23 Further Analysis of Aluminum and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Potential acute health effects of aluminum	• The acute toxicity of metallic aluminum and aluminum compounds is low. In short-term studies using rats, mice, or dogs to various aluminum compounds in the diet or drinking water, only minimal effects were observed at the highest administered doses (HSDB 2014a). Adequate acute inhalation studies have not been identified (HSDB 2014a) and no supporting documentation for the TCEQ threshold is available. The ATSDR has recently completed a toxicological review of aluminum (ATSDR 2008). No studies were located on the effects of acute inhalation exposure to aluminum. Some epidemiological studies on occupationally exposed workers have shown a link between respiratory effects and aluminum exposure. However, workers are often exposed to other chemicals at the same time as the aluminum exposure, making it difficult to determine if the effects were solely related to aluminum. Some occupational exposure studies have also reported neurological effects; however, the association is inconclusive (ATSDR 2008). In a sub-chronic study by Mussi et al. (1984; as cited in ATSDR 2008), no adverse hematological, hepatic, or renal effects were reported from exposure to 1,000 to 6,200 µg aluminum/m^3 for 6 months. Some short-term animal studies have reported respiratory effects from inhalation exposure to aluminum. In a 3-day exposure study by Drew et al. (1974; as cited in ATSDR 2008), hamsters were exposed to 31,000 or 33,000 µg aluminum/m^3 for 3, 6, 10, or 27 days. Pulmonary effects were observed, but the severity decreased with increasing number of exposed days. Hamsters exposed to ≥7,000 µg aluminum/m^3 for 3 days showed a significant increases in absolute lung weights; however, no effects were observed at 3,000 µg aluminum/m^3 (Drew et al. 1974; as cited in ATSDR 2008).
Magnitude of risk	• The predicted peak 1-hour, 95th, and 75th percentile concentrations for aluminum exceed the acute exposure limit at the MPOI for the Construction Case and Application Case and are primarily a result of Project contributions. There were more than 3,000 hourly exceedances of the threshold at the MPOI. As shown on Maps I-2 and I-3 (Appendix I), the Construction and Application Case exceedances of the acute exposure limit are limited to areas around the Project. The highest aluminum concentration predicted at the MPOI was 753 µg/m^3 (Application Case).The effects reported in the above studies are much higher than that predicted at the MPOI. Furthermore, the effects are associated with a longer exposure duration than that considered in this assessment. In addition, there is a low likelihood of a receptor being present at the MPOI, which is along the Project fenceline for both the Construction Case and Application Case. The magnitude of risk for aluminum is considered to be low at the MPOI and negligible at all the other locations evaluated

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; µg/m^3 = micrograms per cubic metre.

Table 5.1-24 Further Analysis of Barium and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 1-hour concentrations at the MPOI for the Construction Case, as well as 75th and 95th percentile concentrations, did not exceed the acute exposure limit. • **Application Case:** The maximum predicted 1-hour concentration at the MPOI (6.1 µg/m^3) exceeded the acute exposure limit of 5 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations and the maximum concentration exceeded the acute exposure limit, while the 75th and 95th percentiles did not exceed the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 0.37 and increased to 0.68 for the Construction Case and 1.2 for the Application Case. The Project Contribution (Construction Case) HQ was 0.68 and the Project Contribution (Operations Only) HQ was 1.2 at the MPOI.
Frequency of exceedances	• There were no exceedances of the threshold for the Construction Case. • There were two hourly exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 1-hour threshold for barium	• A single 1-hour threshold was identified for barium and is an effects screening level obtained from the TCEQ. The TCEQ 1-hour threshold (5 µg/m^3) used in this assessment is based on a health endpoint; however, supporting documentation was not available. Due to the lack of supporting documentation, the conservatism incorporated into the derivation of the acute threshold is unknown.
Potential acute health effects of barium	• Acute exposure to barium can cause irritation of the respiratory tract (HSDB 2014b). No supporting documentation for the TCEQ threshold is available. ATSDR has recently reviewed the toxicity of barium (ATSDR 2007a) and concluded that due to the limited numbers of human and animal studies (eight in total), acute, intermediate, and chronic inhalation effects are not well characterized. Gastrointestinal effects (cramps, nausea, vomiting) and renal failure were reported in one study where a worker was accidentally exposed to an unspecified concentration of barium carbonate powder (Shakle and Keane 1988; as cited in ATSDR 2007a). Musculoskeletal and neurological effects were also reported, but were attributed to low potassium levels, rather than directly from barium exposure. Respiratory effects from chronic inhalation exposure in occupational and animal studies are inconclusive. One human study indicated a minor effect on the lungs in workers (Doig 1976; as cited in ATSDR 2007a), while another indicated no lung abnormalities (Essing et al. 1976; as cited in ATSDR 2007a). • Furthermore, the exposure concentrations and exposure durations were not provided. In one animal study, pulmonary lesions in rats were reported after exposure to 3,600 µg barium/m^3 as barium carbonate for 4 hours/day, 6 days/week for 4 months (Tarasenko et al. 1977; as cited in ATSDR 2007a), while no adverse histological alterations were reported after exposure to 44,100 µg barium/m^3 as barium sulfate for 119 days (Cullen et al. 2000; as cited in ATSDR 2007a). Tarasenko et al. (1977; as cited in ATSDR 2007a) reported cardiovascular, hematological, hepatic, body weight, and metabolic effects in rats exposed to 3,600 µg barium/m^3 as barium carbonate for 4 hours/day, 6 days/week for 4 months. The authors also reported decreased number of sperm, decreased percentage of motile sperm, and decreased osmotic resistance of sperm in male rats exposed to 15,800 µg barium/m^3 as barium carbonate for one cycle of spermatogenesis.

Table 5.1-24 Further Analysis of Barium and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Magnitude of risk	• Only the maximum predicted concentration for the Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95th and 75th percentile concentrations, as well as the Construction Case concentrations, did not exceed the threshold. There were only two hourly exceedances of the threshold at the MPOI. The highest barium concentration predicted at the MPOI was 6.1 µg/m^3 (Application Case). The effects reported in the above studies are much higher than that predicted at the MPOI. Furthermore, the effects are associated with a longer exposure duration than that considered in this assessment. The conservatism in the acute threshold is not known, as supporting documentation is not available. There is a low likelihood of a receptor being present at the MPOI, which is along the Project fenceline for both the Construction Case and Application Case. The magnitude of risk for barium is considered to be negligible at all the locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; µg/m^3 = micrograms per cubic metre.

Table 5.1-25 Further Analysis of Beryllium and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 1-hour concentrations at the MPOI for the Construction Case, as well as 75th and 95th percentile concentrations, did not exceed the acute exposure limit. • **Application Case:** The maximum predicted 1-hour concentration at the MPOI (0.021 µg/m^3) exceeded the acute exposure limit of 0.02 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations and the maximum concentration exceeded the acute exposure limit, while the 75th and 95th percentiles did not exceed the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 0.32 and increased to 0.59 for the Construction Case and 1.1 for the Application Case. The Project Contribution (Construction Case) HQ was 0.59 and the Project Contribution (Operations Only) HQ was 1.1 at the MPOI.
Frequency of exceedances	• There were no exceedances of the threshold for the Construction Case. • There was one hourly exceedance of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 1-hour threshold for beryllium	• A single 1-hour threshold was identified for beryllium and it is an effects screening level obtained from the TCEQ. The TCEQ 1-hour threshold (0.02 µg/m^3) used in this assessment is based on a health endpoint; however, supporting documentation was not available. Due to the lack of supporting documentation, the conservatism incorporated into the derivation of the acute threshold is unknown.

Table 5.1-25 Further Analysis of Beryllium and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Potential acute health effects of beryllium	• Exposure to relatively high concentrations of beryllium (greater than 100 µg/m^3) may cause acute beryllium disease, characterized by chemical pneumonitis (HSDB 2014c). No supporting documentation for the TCEQ threshold is available. According to ATSDR's review of beryllium, acute beryllium disease, or berylliosis, is a respiratory response to beryllium exposure characterized by an inflammation of the respiratory system. Effects range from common cold-like symptoms to severe pneumonitis (ATSDR 2002). Pneumonitis is generally the result of being exposed to concentrations greater than 100 µg beryllium/m^3 as soluble beryllium sulphate or beryllium fluoride (Eisenbud et al. 1948a; as cited in ATSDR 2002). Except for accidental exposures to high concentrations of beryllium, acute beryllium disease is now very uncommon due to occupational health and safety regulations.
Magnitude of risk	• Only the maximum predicted concentration for the Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95th and 75th percentile concentrations, as well as the Construction Case concentrations, did not exceed the threshold. There was only one hourly exceedance of the threshold at the MPOI. The conservatism in the acute threshold is not known as supporting documentation is not available. There is a low likelihood of a receptor being present at the MPOI. The magnitude of risk for beryllium is considered to be negligible at all locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; µg/m^3 = micrograms per cubic metre.

Table 5.1-26 Further Analysis of Cadmium and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 1-hour concentrations at the MPOI for the Construction Case, as well as 75th and 95th percentile concentrations, did not exceed the acute exposure limit. • **Application Case:** The maximum predicted 1-hour concentration at the MPOI (0.12 µg/m^3) exceeded the acute exposure limit of 0.1 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations and the maximum concentration exceeded the acute exposure limit, while the 75th and 95th percentiles did not exceed the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• The HQ for the Base Case and Construction Case was 0.59 and increased to 1.2 for the Application Case. The Project Contribution (Construction Case) HQ was 0.40 and the Project Contribution (Operations Only) HQ was 1.2 at the MPOI.
Frequency of exceedances	• There were no exceedances of the threshold for the Construction Case. • There were three hourly exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.

Table 5.1-26 Further Analysis of Cadmium and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Conservatism in the 1-hour threshold for cadmium	• A single 1-hour threshold was identified for beryllium and it is an effects screening level obtained from the TCEQ. The TCEQ 1-hour threshold (0.1 µg/m^3) used in this assessment is based on a health endpoint; however, supporting documentation was not available. Due to the lack of supporting documentation, the conservatism incorporated into the derivation of the acute threshold is unknown.
Potential acute health effects of cadmium	• Inhalation of cadmium containing fumes generated by welding, soldering, or brazing may cause pneumonitis or acute lung injury (HSDB 2014d). No supporting documentation for the TCEQ threshold is available. ATSDR has recently reviewed the toxicity of cadmium (ATSDR 2012a). The majority of studies involving human exposure to cadmium are in an occupational setting. However, precise estimates of cadmium concentrations leading to acute respiratory effects in humans are not currently available because exposure concentrations were not measured. Respiratory effects from acute inhalation exposure to cadmium are varied as the time post-exposure progresses. During and within 2 hours of exposure, Beton et al. (1966; as cited in ATSDR 2012a) reported coughing and slight irritation of the throat and mucosa in workers exposed to 8,630 µg/m^3 cadmium oxide. From 4 to 10 hours post-exposure, influenza-like symptoms began to appear and from 8 hours to 7 days post-exposure, more advanced stages of pulmonary responses were evident (severe shortness of breath and wheezing, chest pain, persistent cough, weakness and malaise, anorexia, nausea, diarrhea, and abdominal pain). Animal, but not human, studies have reported reduced body weights due to acute inhalation exposures. In one study, male rats exposed to 112,000 µg cadmium/m^3 as cadmium oxide fumes had a significant reduction in body weight (Rusch et al. 1986; as cited in ATSDR 2012a). In another study, Buckley and Bassett (1987b; as cited in ATSDR 2012a) reported the same result at an exposure concentration of 4,600 µg cadmium/m^3 and duration of 3 hours. Hematological effects of acute inhalation exposure to cadmium in humans and animals are inconclusive.
Magnitude of risk	• Only the maximum predicted concentration for the Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95th and 75th percentile concentrations, as well as the Construction Case concentrations, did not exceed the threshold. There were only two (Application Case) hourly exceedances of the threshold at the MPOI. The highest cadmium concentration predicted at the MPOI was 0.12 µg/m^3 (Application Case). The effects reported in the above studies are much higher than that predicted at the MPOI. The conservatism in the acute threshold is not known, as supporting documentation is not available. There is a low likelihood of a receptor being present at the MPOI. The magnitude of risk for cadmium is considered to be negligible at all locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; µg/m^3 = micrograms per cubic metre.

Table 5.1-27 Further Analysis of Chromium (VI) and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 1-hour concentration at the MPOI (1.1 µg/m^3) exceeded the acute exposure limit of 0.1 µg/m^3. The 95th percentile concentration (0.43 µg/m^3) also exceeded the acute exposure limit at the MPOI, while the 75th percentile concentration did not. The Project Contribution (Construction Only) concentrations were similar to the Construction Case concentrations, with the maximum and 95th percentile concentrations exceeding the acute exposure limit and the 75th percentile concentrations not exceeding the acute exposure limit. • **Application Case:** The maximum predicted 1-hour concentration at the MPOI (1.9 µg/m^3) exceeded the acute exposure limit of 0.1 µg/m^3. The 95th percentile concentration (0.36 µg/m^3) also exceeded the acute exposure limit at the MPOI, while the 75th percentile concentration did not. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations, with the maximum and 95th percentile concentrations exceeding the acute exposure limit and the 75th percentile concentrations not exceeding the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• The HQ for the Base Case was 5.8 and increased to 11 for the Construction Case and 19 for the Application Case. The Project Contribution (Construction Case) HQ was 11 and the Project Contribution (Operations Only) HQ was 19 at the MPOI.
Frequency of exceedances	• There were 2,010 hourly exceedances of the threshold at the MPOI for the Construction Case, based on a year of modelling. • There were 1,892 hourly exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The primary emission source of chromium is road dust. Other emission sources include bulldozing and crushing, screening, and conveying of ore and waste rock. The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. No information on speciation of chromium was available for the air emissions; thus, it was conservatively assumed that 100% of the air emissions could be chromium (VI). This is likely an overestimate of the proportion of chromium (VI) in the emissions. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 1-hour threshold for chromium	• A threshold of 0.1 µg/m^3 for chromium (VI) was adopted from TCEQ. The threshold for hexavalent chromium is based on a health endpoint, but no supporting documentation is available.
Potential acute health effects of chromium	• Acute exposure to high levels of chromium can cause eye irritation (chromium particles), pulmonary fibrosis, and bronchial asthma (HSDB 2014e). The ATSDR has recently reviewed the toxicity of chromium (ATSDR 2012c). There is limited information regarding the effects of chromium (VI) from acute inhalation exposure. One study reported respiratory, gastrointestinal, and body weight (anorexia) effects in workers exposed to “massive amounts” of chromium (Meyers 1950; as cited in ATSDR 2012c), but no information was provided on the exposure concentration. Most epidemiological studies are based on intermediate to chronic duration, and effects are not always conclusive due to the many confounding variables in the chromium industry (e.g., information on smoking habits). Upper respiratory effects have been reported in electroplating workers exposed to 90 to 730 µg chromium (VI)/m^3 for 0.5 to 12 months (Kleinfeld and Rosso 1965; as cited in ATSDR 2012c). Respiratory effects have been reported at lower concentrations in several studies, but these studies are for a chronic duration. Studies with animals have also shown respiratory effects associated with chromium VI exposure. The duration of these studies ranged from 28 to 90 days and exposure concentrations ranged from 50 to 1,150 µg chromium (VI)/m^3.

Table 5.1-27 Further Analysis of Chromium (VI) and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Magnitude of risk	• The maximum and 95th percentile concentrations exceeded the acute threshold at the MPOI for the Construction Case and the Application Case, primarily a result of the Project contribution. There were over 2,000 hourly exceedances of the threshold at the MPOI. The maximum chromium (VI) concentration, 1.9 µg/m^3, was predicted for the Application Case and is much lower than the concentrations reported above in sub-chronic toxicological studies. Furthermore, the effects are associated with a longer exposure duration than that considered in this assessment. The air predictions are likely an overestimate of chromium (VI) concentrations due to the assumption of 100% speciation as chromium (VI). The conservatism in the acute threshold is not known, as supporting documentation is not available. There is a low likelihood of a receptor being present at the MPOI. As shown on Maps I-5 and I-6 (Appendix I), the Construction and Application Case exceedances of the acute exposure limit are limited to areas around the Project. The magnitude of risk for chromium is considered to be low at the MPOI and negligible at all other locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; µg/m^3 = micrograms per cubic metre.

Table 5.1-28 Further Analysis of Iron and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 1-hour concentration at the MPOI (99 µg/m^3) exceeded the acute exposure limit of 10 µg/m^3. The 95th percentile concentration (40 µg/m^3) also exceeded the acute exposure limit at the MPOI, while the 75th percentile concentration did not. The Project Contribution (Construction Only) concentrations were similar to the Construction Case concentrations, with the maximum and 95th percentile concentrations exceeding the acute exposure limit and the 75th percentile concentrations not exceeding the acute exposure limit. • **Application Case:** The maximum predicted 1-hour concentration at the MPOI (179 µg/m^3) exceeded the acute exposure limit of 10 µg/m^3. The 95th percentile concentration (34 µg/m^3) also exceeded the acute exposure limit at the MPOI, while the 75th percentile concentration did not. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations, with the maximum and 95th percentile concentrations exceeding the acute exposure limit and the 75th percentile concentrations not exceeding the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 5.4 and increased to 9.9 for the Construction Case and 18 for the Application Case. The Project Contribution (Construction Case) HQ was 9.9 and the Project Contribution (Operations Only) HQ was 18 at the MPOI.
Frequency of exceedances	• There were 1,879 hourly exceedances of the threshold at the MPOI for the Construction Case, based on a year of modelling. • There were 1,721 hourly exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.

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Table 5.1-28 Further Analysis of Iron and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Conservatism and uncertainty in air predictions	• The primary emission source of iron is road dust. Other emission sources include bulldozing and crushing, screening, and conveying of waste rock and ore. The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 1-hour threshold for iron	• A single 1-hour threshold was identified for iron and is an effects screening level obtained from the TCEQ. The TCEQ 1-hour threshold (10 µg/m^3) used in this assessment is based on a health endpoint; however, supporting documentation was not available. Due to the lack of supporting documentation, the conservatism incorporated into the derivation of the acute threshold is unknown.
Potential acute health effects of iron	• Acute inhalation effects of ferric salts as dusts and mists include irritation of the respiratory tract and irritation of the skin (HSDB 2014f). In terms of chronic exposure, the American Conference of Governmental Industrial Hygienists (ACGIH) have established the following Threshold Limit Value-Time Weighted Average Values for occupational workers: 1,000 µg/m^3 to reduce the likelihood of irritation to eyes, skin, and respiratory tract from exposure to aerosols or mists of soluble iron salts (ferrous and ferric sulfates and chlorides, and ferric nitrate); and 5,000 µg/m^3 for dusts and fumes of ferric oxide to protect against iron deposition in lung tissues (ACGIH 1991, 2001; as cited in US EPA 2006). In a literature review completed by the US EPA (2006), no reliable human studies were available on the acute toxicity of iron inhalation. In an animal study, rabbits exposed to 3,100 µg/m^3 iron for 6 hours/day, 5 days/week for 2 months exhibited alterations in the lungs (histopathological changes, lung spots, increased lung weights) (Johansson et al. 1992; as cited in US EPA 2006).
Magnitude of risk	• The maximum and 95th percentile concentrations exceeded the acute threshold at the MPOI for the Construction Case and Application Case, primarily a result of the Project contribution. There were close to 2,000 hourly exceedances of the threshold at the MPOI. The maximum concentration was 179 µg/m^3 (Application Case), which is well below the occupational thresholds set by the ACGIH for a more chronic exposure and the concentrations at which effects are expected to occur. The conservatism in the acute threshold is not known, as supporting documentation is not available. As shown on Maps I-8 and I-9 (Appendix I), the Construction and Application Case exceedances of the acute exposure limit are limited to areas around the Project. There is a low likelihood of a receptor being present at the MPOI, which is along the Project fenceline for both the Construction Case and Application Case. The magnitude of risk for iron is considered to be low at the MPOI and negligible at all the other locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; US EPA = United States Environmental Protection Agency; µg/m^3 = micrograms per cubic metre.

Table 5.1-29 Further Analysis of Manganese and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 1-hour concentrations at the MPOI for the Construction Case, as well as 75th and 95th percentile concentrations, did not exceed the acute exposure limit. • **Application Case:** The maximum predicted 1-hour concentration at the MPOI (2.7 µg/m³) exceeded the acute exposure limit of 2 µg/m³. The 75th and 95th percentile concentrations did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations and the maximum concentration exceeded the acute exposure limit, while the 75th and 95th percentile concentrations did not.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 0.41 and increased to 0.76 for the Construction Case and 1.4 for the Application Case. The Project Contribution (Construction Case) HQ was 0.76 and the Project Contribution (Operations Only) HQ was 1.4 at the MPOI.
Frequency of exceedances	• There were no exceedances of the threshold for the Construction Case. • There were nine hourly exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The primary emission source of manganese is road dust. Other emission sources include bulldozing, crushing, screening, and conveying of ore and waste rock. The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 1-hour threshold for manganese	• A single 1-hour threshold was identified for manganese and is an effects screening level obtained from the TCEQ. The TCEQ 1-hour threshold (2 µg/m³) used in this assessment is based on a health endpoint; however, supporting documentation was not available. Due to the lack of supporting documentation, the conservatism incorporated into the derivation of the acute threshold is unknown.
Potential acute health effects of manganese	• Neurotoxicity is the primary toxicological endpoint associated with manganese exposure (HSDB 2014g). The ATSDR has recently reviewed the toxicity of manganese (ATSDR 2012b), and indicates that limited information is available regarding the acute inhalation toxicity of manganese. Manganism, a term used to define the neurotoxic effects of manganese, has been reported in several epidemiological studies. Exposure concentrations ranged from 70 to 970 µg manganese/m³. Some workers may show symptoms within 1 to 3 months (Rodier 1955; as cited in ATSDR 2012b), but symptoms are generally not observed until after several years of exposure.
Magnitude of risk	• Only the maximum predicted concentration for the Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95th and 75th percentile concentrations, as well as the Construction Case concentrations, did not exceed the threshold. There were less than 10 hourly exceedances of the threshold at the MPOI. The highest manganese concentration predicted at the MPOI was 2.7 µg/m³ (Application Case). The effects reported in the above studies are much higher than that predicted at the MPOI. The conservatism in the acute threshold is not known as supporting documentation is not available. There is a low likelihood of a receptor being present at the MPOI. The magnitude of risk for manganese is considered to be negligible at all the locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; µg/m³ = micrograms per cubic metre.

Table 5.1-30 Further Analysis of Nickel and Determination of Magnitude of Risk (Acute 1-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 1-hour concentrations at the MPOI for the Construction Case, as well as 75th and 95th percentile concentrations, did not exceed the acute exposure limit. • **Application Case:** The maximum predicted 1-hour concentration at the MPOI (0.60 µg/m^3) exceeded the acute exposure limit of 0.33 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations and the maximum concentration exceeded the acute exposure limit, while the 75th and 95th percentile concentrations did not.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 0.32 and increased to 0.42 for the Construction Case and 1.8 for the Application Case. The Project Contribution (Construction Only) HQ was 0.42 and the Project Contribution (Operations Only) HQ was 1.8 at the MPOI.
Frequency of exceedances	• There were no exceedances of the threshold for the Construction Case. • There were 24 hourly exceedances of the threshold at the MPOI for the Application Case and 24, based on a year of modelling.
Conservatism and uncertainty in air predictions	• Road dust and crushing, screening, and conveying of ore and waste rock are the primary emission sources for nickel. The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 1-hour threshold for nickel	• The TCEQ threshold was based on significant bronchial constriction in 12 metal plating factory workers with occupational asthma exposed to an aerosol of 0.3 mg/m^3 of nickel sulfate (67 µg nickel/m^3) for 30 minutes. The exposure concentration was extrapolated to 1-hour (33.5 µg nickel/m^3) and an uncertainty factor of 30 (10 for using a LOAEL and 3 for an incomplete database) was applied.
Potential acute health effects of nickel	• Acute inhalation exposure may cause respiratory effects. According to ATSDR's review of the inhalation toxicity of nickel, human studies are limited to occupational exposures, with the majority focusing on chronic durations and a cancer endpoint (ATSDR 2005). The two studies reviewed on non-cancer endpoints are not reliable, as workers were exposed to other metals at the same time, making it difficult to determine if the effects were solely related to nickel exposure. NTP (1996b, 1996c; as cited in ATSDR 2005) reported chronic inflammation in rats exposed to 700 µg nickel/m^3 as nickel sulphate and 440 µg nickel/m^3 as nickel subsulphide for 6 hours/day for 12 days. Exposure to 700 µg nickel/m^3 as nickel sulphate and 3,650 µg nickel/m^3 as nickel subsulphide resulted in decreased body weights in rats. The authors also reported that following acute- or intermediate exposure, nickel toxicity is related to its solubility, with soluble nickel sulfate being the most toxic and insoluble nickel oxide being the least toxic (NTP 1996b, 1996c; as cited in ATSDR 2005).
Magnitude of risk	• Only the maximum predicted concentration for the Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95th and 75th percentile concentrations, as well as the Construction Case concentrations, did not exceed the threshold. There were less than 25 hourly exceedances of the threshold at the MPOI. The acute threshold is considered conservative as an uncertainty factor of 30 was applied to a human study. There is a low likelihood of a receptor being present at the MPOI (approximately the Project Boundary). The magnitude of risk for nickel is considered to be low and likely negligible at the MPOI and negligible at all other locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; LOAEL = lowest observed adverse effect level; NTP = National Toxicology Program; µg/m^3 = micrograms per cubic metre.

Table 5.1-31 Further Analysis of Nitrogen Dioxide and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 24-hour concentrations at the MPOI for the Construction Case, as well as 75th and 95th percentile concentrations, did not exceed the acute exposure limit. • **Application Case:** The maximum predicted 24-hour concentration at the MPOI (321 µg/m^3) exceeded the acute exposure limit of 200 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Construction Case concentrations and the maximum concentration exceeded the acute exposure limit, while the 75th and 95th percentile concentrations did not.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 0.70 and increased to 0.73 for the Construction Case and 1.6 for the Application Case. The Project Contribution (Construction Case) HQ was 0.73 and the Project Contribution (Operations Only) HQ was 1.6 at the MPOI.
Frequency of exceedances	• There were no exceedances of the threshold for the Construction Case. • There was one daily exceedance of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The air emission sources for the Project were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 24-hour threshold for nitrogen dioxide	• A threshold of 200 µg/m^3 was adopted from the Northwest Territories, CCME, and OMOE. This threshold is not health based but was derived from a maximum acceptable limit at which odour is perceived. Additional information on the derivation of this threshold was not found; however, the use of an aesthetic threshold instead of a health threshold can be a conservative approach.
Potential acute health effects of nitrogen dioxide	• Short-term inhalation exposure to nitrogen dioxide may irritate the respiratory tract (HSDB 2014h). Studies with asthmatic volunteers indicate that this group may be more sensitive to the effects of nitrogen dioxide than healthy individuals. Increased airway reactivity has been reported in several studies with asthmatic volunteers exposed to concentrations ranging from 470 to 900 µg/m^3 (Bauer et al. 1986, Mohsenin 1987, Rubinstein et al. 1990, Avol et al. 1988, Roger et al. 1990; as cited in Cal EPA OEHHA 2008).
Magnitude of risk	• Only the maximum predicted concentration for the Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95th and 75th percentile concentrations, as well as the Construction Case concentrations, did not exceed the threshold. There was only 1 daily exceedance of the threshold at the MPOI. There is a low likelihood of a receptor being present at the MPOI (approximately the Project Boundary). The magnitude of risk for nitrogen dioxide is considered to be negligible at all the locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; CCME = Canadian Council of Ministers of the Environment; OMOE = Ontario Ministry of the Environment; µg/m^3 = micrograms per cubic metre.

Table 5.1-32 Further Analysis of Aluminum and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 24-hour concentration at the MPOI (193 µg/m^3) and 95th percentile concentration (134 µg/m^3) exceeded the acute exposure limit of 120 µg/m^3. The 75th percentile concentration did not exceed the acute exposure limit at the MPOI. The Project Contribution (Construction Only) concentrations were similar to the Construction Case concentrations, with maximum and 95th percentile concentrations exceeding the acute exposure limit and 75th percentile concentrations not exceeding the acute exposure limit. • **Application Case:** The maximum predicted 24-hour concentration at the MPOI (271 µg/m^3) exceeded the acute exposure limit of 120 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Construction Case concentrations, with the maximum concentration exceeding the acute exposure limit and the 75th and 95th percentile concentrations not exceeding the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 0.58 and increased to 1.6 for the Construction Case and 2.3 for the Application Case. The Project Contribution (Construction Case) HQ was 1.6 and the Project Contribution (Operations Only) HQ was 2.3 at the MPOI.
Frequency of exceedances	• There were 23 daily exceedances of the threshold at the MPOI for the Construction Case, based on a year of modelling. • There were 17 daily exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The primary emission source of aluminum is road dust. Other emission sources include bulldozing, crushing, screening, and conveying of ore and waste rock. The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 24-hour threshold for aluminum	• A single 24-hour threshold was identified for aluminum from the OMOE. The OMOE 24-hour threshold (120 µg/m^3) used in this assessment is based on a health endpoint; however, supporting documentation was not available. Due to the lack of supporting documentation, the conservatism incorporated into the derivation of the threshold is unknown.
Potential acute health effects of aluminum	• The acute toxicity of metallic aluminum and aluminum compounds is low. In short-term studies using rats, mice, or dogs to various aluminum compounds in the diet or drinking water, only minimal effects were observed at the highest administered doses (HSDB 2014a). Adequate acute inhalation studies have not been identified (HSDB 2014a). The ATSDR has recently completed a toxicological review of aluminum (ATSDR 2008). No studies were located on the effects of acute inhalation exposure to aluminum. Some epidemiological studies on occupationally exposed workers have shown a link between respiratory effects and aluminum exposure. However, workers are often exposed to other chemicals at the same time as the aluminum exposure, making it difficult to determine if the effects were solely related to aluminum. Some occupational exposure studies have also reported neurological effects; however, the association is inconclusive (ATSDR 2008). In a sub-chronic study by Mussi et al. (1984; as cited in ATSDR 2008), no adverse hematological, hepatic, or renal effects were reported from exposure to 1,000 to 6,200 µg aluminum/m^3 for 6 months. Some short-term animal studies have reported respiratory effects from inhalation exposure to aluminum. In a 3-day exposure study by Drew et al. (1974; as cited in ATSDR 2008), hamsters were exposed to 31,000 or 33,000 µg aluminum/m^3 for 3, 6, 10, or 27 days. Pulmonary effects were observed, but the severity decreased with increasing number of exposed days. Hamsters exposed to ≥7,000 µg aluminum/m^3 for 3 days showed a significant increases in absolute lung weights; however, no effects were observed at 3,000 µg aluminum/m^3 (Drew et al. 1974; as cited in ATSDR 2008).

Table 5.1-32 Further Analysis of Aluminum and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Magnitude of risk	• The predicted maximum 24-hour and 95th percentile concentrations for aluminum exceed the acute exposure limit at the MPOI for the Construction Case, primarily a result of the Project contribution. The maximum 24-hour concentration also exceeded the acute exposure limit at the MPOI for the Application Case, primarily a result of the Project contribution. There were up to 23 daily exceedances of the acute exposure limit at the MPOI. The conservatism in the acute threshold is not known, as supporting documentation is not available. There is a low likelihood of a receptor being present at the MPOI (approximately the Project Boundary). The magnitude of risk for aluminum is considered to be negligible at all the locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; ATSDR = Agency for Toxic Substances and Disease Registry; OMOE = Ontario Ministry of the Environment; µg/m^3 = micrograms per cubic metre.

Table 5.1-33 Further Analysis of Cadmium and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 24-hour concentrations at the MPOI for the Construction Case, as well as 75th and 95th percentile concentrations, did not exceed the acute exposure limit. • **Application Case:** The maximum predicted 24-hour concentration at the MPOI (0.057 µg/m^3) exceeded the acute exposure limit of 0.03 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations, with maximum concentrations exceeding the acute exposure limit, and 75th and 95th percentile concentrations not exceeding the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 0.56 and increased to 0.79 for the Construction Case and 1.9 for the Application Case. The Project Contribution (Construction Case) HQ was 0.79 and the Project Contribution (Operations Only) HQ was 1.9 at the MPOI.
Frequency of exceedances	• There were no exceedances of the threshold for the Construction Case. • There were 10 daily exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 24-hour threshold for cadmium	• A threshold of 0.03 µg/m^3 was adopted from the ATSDR. The tthreshold is based on a LOAEL of 0.088 mg/m^3 for respiratory effects in rats exposed to cadmium oxide for 6.2 hours/day, 5 days/week for 2 weeks. The LOAEL was adjusted for continuous exposure (0.088 mg Cd/m^3 x 6.2 hours/24 hours x 5 days/7 days) and for a regional deposited dose ratio for the pulmonary region of 0.617. An uncertainty factor of 300 (3 for extrapolating from animals to humans, 10 for a use of a LOAEL and 10 for human variability) was applied to the human equivalent concentration (0.01 mg/m^3).

Table 5.1-33 Further Analysis of Cadmium and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Potential acute health effects of cadmium	• The ATSDR 24-hour threshold is based on respiratory effects. ATSDR has recently reviewed the toxicity of cadmium (ATSDR 2012a). The majority of studies involving human exposure to cadmium are in an occupational setting. However, precise estimates of cadmium concentrations leading to acute respiratory effects in humans are not currently available because exposure concentrations were not measured. Respiratory effects from acute inhalation exposure to cadmium are varied as the time post-exposure progresses. During and within 2 hours of exposure, Beton et al. (1966; as cited in ATSDR 2012a) reported coughing and slight irritation of the throat and mucosa in workers exposed to 8,630 µg/m^3 cadmium oxide. From 4 to 10 hours post-exposure, influenza-like symptoms began to appear and from 8 hours to 7 days post-exposure, more advanced stages of pulmonary responses were evident (severe shortness of breath and wheezing, chest pain and precordial constriction, persistent cough, weakness and malaise, anorexia, nausea, diarrhea, nocturia, abdominal pain, hemoptysis, and prostration). Animal, but not human, studies have reported reduced body weights due to acute inhalation exposures. In one study, male rats exposed to 112,000 µg cadmium/m^3 as cadmium oxide fumes had a significant reduction in body weight (Rusch et al. 1986; as cited in ATSDR 2012a). In another study, Buckley and Bassett (1987b; as cited in ATSDR 2012a) reported the same result at an exposure concentration of 4,600 µg cadmium/m^3 and duration of 3 hours. Hematological effects of acute inhalation exposure to cadmium in humans and animals are inconclusive.
Magnitude of risk	• Only the maximum predicted concentration for the Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95th and 75th percentile concentrations, as well as the Construction Case concentrations, did not exceed the threshold. There were up to 10 hourly exceedances of the threshold at the MPOI. An uncertainty factor of 300 was applied in the derivation of the acute threshold, and it is considered conservative. There is a low likelihood of a receptor being present at the MPOI (approximately the Project Boundary). The magnitude of risk for cadmium is considered to be negligible at all the locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; ATSDR = Agency for Toxic Substances and Disease Registry; LOAEL = lowest observed adverse effect level; µg/m^3 = micrograms per cubic metre.

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Table 5.1-34 Further Analysis of Chromium (VI) and Chromium (III) and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** As chromium speciation data were not available, it was assumed that chromium was entirely either in the hexavalent form or the trivalent form for assessment purposes. The maximum predicted 24-hour chromium concentration at the MPOI (0.49 µg/m^3) exceeded the acute chromium (VI) exposure limit of 0.39 µg/m^3, but not the chromium (III) exposure limit of 0.5 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limits of either chromium species. The Project Contribution (Construction Only) chromium (VI) concentrations were similar to the Construction Case concentrations, with maximum concentrations exceeding the acute exposure limit, and 75th and 95th percentile concentrations not exceeding the acute exposure limit. The maximum, 75th percentile, or 95th percentile concentrations did not exceed the chromium (III) exposure limits for the Project Contribution (Construction Only). • **Application Case:** The maximum predicted 24-hour concentration at the MPOI (0.69 µg/m^3) exceeded the acute chromium (VI) exposure limit of 0.39 µg/m^3 and the acute chromium (III) exposure limit of 0.5 µg/m^3. The 75th and 95th percentile concentrations did not exceed the acute exposure limits of either chromium species. The Project Contribution (Operations Only) chromium (VI) and chromium (III) concentrations were similar to the Application Case concentrations, with maximum concentrations exceeding the acute exposure limit and 75th and 95th percentile concentrations not exceeding the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the chromium (VI) HQ for the Base Case was 0.45 and increased to 1.3 for the Construction Case and 1.8 for the Application Case. The Project Contribution (Construction Case) chromium (VI) HQ was 1.3 and the Project Contribution (Operations Only) HQ was 1.8 at the MPOI. At the MPOI, the chromium (III) HQ for the Base Case was 0.35 and increased to 0.99 for the Construction Case and 1.4 for the Application Case. The Project Contribution (Construction Only) chromium (III) HQ was 1.0 and the Project Contribution (Operations Only) HQ was 1.4 at the MPOI.
Frequency of exceedances	• There were nine daily exceedances of the chromium (VI) threshold and no daily exceedances of the chromium (III) threshold at the MPOI for the Construction Case, based on a year of modelling. • There were eight daily exceedances of the chromium (VI) threshold and two daily exceedances of the chromium (III) threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The primary emission source of chromium is road dust. Other emission sources include bulldozing, crushing, screening, and conveying of ore and waste rock. The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. No information was available on the speciation of chromium in the air modelling; as such, it was conservatively assumed that 100% of the chromium was present as chromium (VI). However, it has been estimated that approximately one-third of the atmospheric releases of chromium are in the chromium (VI) form (ATSDR 2012c). In the atmosphere, chromium (VI) may be reduced to chromium (III), with an estimated half-life of 16 hours to 5 days (ATSDR 2012c). Thus, it is considered that the proportion of chromium (VI) present in ambient air is likely to be less than 50%, with the percentage potentially dropping as reduction to chromium (III) in the atmosphere occurs each day. This is likely an overestimate of the proportion of chromium (VI) in the emissions. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 24-hour threshold for chromium	• A threshold of 0.39 µg/m^3 was adopted from the TCEQ. A threshold of 0.5 µg/m^3 has been recommended by the OMOE. Adopting the lowest available threshold is considered a conservative approach.

Table 5.1-34 Further Analysis of Chromium (VI) and Chromium (III) and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Potential acute health effects of chromium	• The TCEQ threshold is based on a $BMCL_{10}$ (benchmark concentration lower confidence limit corresponding to the lower 10% incidence of effect) of 16.06 µg Cr(VI)/m^3 for increased relative lung weight in rats exposed to 0, 50, 100, 200, or 400 µg Cr(VI)/m^3, as sodium dichromate, for 22 hours/day for 7 days/week for 30 days. The $BMCL_{10}$ was adjusted for a human equivalent concentration (HEC) of 2.41. Uncertainty factors for interspecies variation (3) and intraspecies variation (10) were applied. The resulting threshold of 1.3 µg Cr(VI)/m^3 was based on an HQ = 1.0. The screening level was derived by adjusting to an HQ = 0.3, by dividing the value of 1.3 µg Cr(VI)/m^3 by 3.3, resulting in a value of 0.39 µg Cr(VI)/m^3. • The OMOE threshold is (for metallic Cr(0), Cr(II), and Cr(III)) based on increased total lung and trachea weight relative to body weight in rats associated with exposure to Cr(III). Rats were exposed to chromium sulfate for 13 weeks (5 days/week, 6 hours/day). The point of departure (POD) was 3.45 mg/m^3 (a benchmark concentration lower confidence limit corresponding to a 10% incidence of effect [$BMCL_{10}$]) and was adjusted for continuous exposure (0.616 mg/m^3) and regional deposited dose ratio (to account for differences in deposition pattern of inhaled particles in the respiratory tract in humans and test animals; 1.315 for the entire respiratory tract). The POD adjusted for a HEC (POD_{HEC}) was 0.8086 mg/m^3. An uncertainty factor of 300 (10 for human variability, 10 for extrapolating from subchronic to chronic exposure and 3 for extrapolation from animals to humans) was applied.
Magnitude of risk	• Only the maximum predicted concentration for the Construction Case and Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95^{th} and 75^{th} percentile concentrations did not exceed the threshold. There were less than 10 daily exceedances of the threshold at the MPOI. The air predictions are likely an overestimate of chromium (VI) concentrations due to the assumption of 100% speciation as chromium (VI). There is a low likelihood of a receptor being present at the MPOI (approximately the Project Boundary). The magnitude of risk for chromium is considered negligible at all the locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; TCEQ = Texas Commission on Environmental Quality; ATSDR = Agency for Toxic Substances and Disease Registry; Cr = chromium; OMOE = Ontario Ministry of the Environment.

Table 5.1-35 Further Analysis of Iron and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95^{th}, and 75^{th} percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 24-hour concentration at the MPOI (46 µg/m^3) exceeded the acute exposure limit of 4 µg/m^3. The 75^{th} (10 µg/m^3) and 95^{th} (32 µg/m^3) percentile concentrations also exceeded the acute exposure limit at the MPOI. The Project Contribution (Construction Only) concentrations were similar to the Construction Case concentrations and maximum, 75^{th}, and 95^{th} percentile concentrations exceeded the acute exposure limit. • **Application Case:** The maximum predicted 24-hour concentration at the MPOI (64 µg/m^3) exceeded the acute exposure limit of 4 µg/m^3. The 75^{th} (9.6 µg/m^3) and 95^{th} (27 µg/m^3) percentile concentrations also exceeded the acute exposure limit at the MPOI. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations and maximum, 75^{th}, and 95^{th} percentile concentrations exceeded the acute exposure limit.

Table 5.1-35 Further Analysis of Iron and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 4.1 and increased to 11 for the Construction Case and 16 for the Application Case. The Project Contribution (Construction Case) HQ was 11 and the Project Contribution (Operations Only) HQ was 16 at the MPOI.
Frequency of exceedances	• There were 194 daily exceedances of the threshold at the MPOI for the Construction Case, based on a year of modelling. • There were 197 daily exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The primary emission source of iron is road dust. Other emission sources include bulldozing, crushing, screening, and conveying of ore and waste rock. The Project air emission sources were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 24-hour threshold for iron	• A single 24-hour threshold was identified for iron from the OMOE. The OMOE 24-hour threshold (4 $\mu g/m^3$) used in this assessment is based on a health endpoint; however, supporting documentation was not available. Due to the lack of supporting documentation, the conservatism incorporated into the derivation of the threshold is unknown.
Potential acute health effects of iron	• Acute inhalation effects of ferric salts as dusts and mists include irritation of the respiratory tract and irritation of the skin (HSDB 2014f). In terms of chronic exposure, the American Conference of Governmental Industrial Hygienists (ACGIH) have established the following Threshold Limit Value-Time Weighted Average Values for occupational workers: 1,000 $\mu g/m^3$ to reduce the likelihood of irritation to eyes, skin, and respiratory tract from exposure to aerosols or mists of soluble iron salts (ferrous and ferric sulfates and chlorides, and ferric nitrate); and 5,000 $\mu g/m^3$ for dusts and fumes of ferric oxide to protect against iron deposition in lung tissues (ACGIH 1991, 2001; as cited in US EPA 2006). In a literature review completed by the US EPA (2006), no reliable human studies were identified on the acute inhalation toxicity of iron. In an animal study, rabbits exposed to 3,100 $\mu g/m^3$ iron for 6 hours/day, 5 days/week for 2 months exhibited alterations in the lungs (histopathological changes, lung spots, increased lung weights) (Johansson et al. 1992; as cited in US EPA 2006).
Magnitude of risk	• The predicted maximum 24-hour, 95th, and 75th percentile concentrations for iron exceed the acute exposure limit at the MPOI for the Construction Case and Application Case, primarily a result of the Project contribution. There were close to 200 daily exceedances of the threshold at the MPOI. The maximum concentration was 64 $\mu g/m^3$ (Application Case), which is well below the occupational thresholds set by the ACGIH and the concentrations at which effects are expected to occur. The conservatism in the acute threshold is not known, as supporting documentation is not available. As shown on Maps I-11 and I-12 (Appendix I), the Construction and Application Case exceedances of the acute exposure limit are limited to areas around the Project. There is a low likelihood of a receptor being present at the MPOI, which is along the Project fenceline for both the Construction Case and Application Case. The magnitude of risk for iron is considered to be low at the MPOI and negligible at all the other locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; US EPA = United States Environmental Protection Agency; OMOE = Ontario Ministry of the Environment; $\mu g/m^3$ = micrograms per cubic metre.

Table 5.1-36 Further Analysis of Manganese and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 24-hour concentration at the MPOI (0.70 µg/m^3) exceeded the acute exposure limit of 0.1 µg/m^3. The 75th (0.16 µg/m^3) and 95th (0.49 µg/m^3) percentile concentrations also exceeded the acute exposure limit at the MPOI. The Project Contribution (Construction Only) concentrations were similar to the Construction Case concentrations and maximum, 75th and 95th percentile concentrations exceeded the acute exposure limit. • **Application Case:** The maximum predicted 24-hour concentration at the MPOI (0.98 µg/m^3) exceeded the acute exposure limit of 0.1 µg/m^3. The 75th (0.15 µg/m^3) and 95th (0.42 µg/m^3) percentile concentrations also exceeded the acute exposure limit at the MPOI. The Project Contribution (Operations Only) concentrations were similar to the Applications Case concentrations and maximum, 75th, and 95th percentile concentrations exceeded the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 2.5 and increased to 7.0 for the Construction Case and 9.8 for the Application Case. The Project Contribution (Construction Case) HQ was 7.0 and the Project Contribution (Operations Only) HQ was 9.8 at the MPOI.
Frequency of exceedances	• There were 135 daily exceedances of the threshold at the MPOI for the Construction Case, based on a year of modelling. • There were 139 daily exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• The primary emission source of manganese is road dust. Other emission sources include bulldozing, crushing, screening, and conveying of ore and waste rock. The sources of air emissions for the Project were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.
Conservatism in the 24-hour threshold for manganese	• A threshold of 0.1 µg/m^3 was adopted from the OMOE. The threshold is for manganese as a metal/parameter in $PM_{2.5}$ and based on an occupational study where workers were exposed to MnO_2 dust for an average of 5.3 years in a dry-cell battery factory. The point of departure (POD) was selected as 84 µg/m^3 (benchmark concentration lower confidence limit corresponding to a 5% response level [$BMCL_{05}$]) for a logistic dose-response model of eye-hand coordination scores. The POD was adjusted for continuous exposure (30 µg/m^3) and an uncertainty factor of 300 (10 for human variability, 3 for database limitations and differences in toxicity associated with different species of manganese, 3 for the vulnerability of the developing nervous system, and 3 for subchronic to chronic exposure extrapolation) was applied.
Potential acute health effects of manganese	• Neurotoxicity is the primary symptom of manganese toxicity resulting from chronic exposure (HSDB 2014g). ATSDR has recently reviewed the toxicity of manganese (ATSDR 2012b) and indicated that there is limited information regarding the acute inhalation toxicity of manganese. Manganism, a term used to define the neurotoxic effects of manganese, has been reported in several epidemiological studies. Exposure concentrations ranged from 70 to 970 µg manganese/m^3. Some workers may show symptoms within 1 to 3 months (Rodier 1955; as cited in ATSDR 2012b), but symptoms are generally not observed until several years after exposure. The highest manganese concentration predicted at the MPOI was 0.98 µg/m^3 (Application Case). The concentrations corresponding with effects reported in the above studies are much higher than that predicted at the MPOI.

Table 5.1-36 Further Analysis of Manganese and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Magnitude of risk	• The predicted maximum 24-hour, 95th, and 75th percentile concentrations for manganese exceeded the acute exposure limit at the MPOI for the Construction Case and Application Case, primarily a result of the Project contribution. There were close to 140 daily exceedances of the threshold at the MPOI. The maximum predicted concentration of manganese was 0.98 µg/m^3 (Application Case), which is much lower than the concentrations where effects are expected to occur. Furthermore, the effects are associated with a longer exposure duration than that considered in this assessment. As shown on Maps I-14 and I-15 (Appendix I), the Construction and Application Case exceedances of the acute exposure limit are limited to areas around the Project. There is a low likelihood of a receptor being present at the MPOI. The magnitude of risk for manganese is considered to be low at the MPOI and negligible at all the other locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; ATSDR = Agency for Toxic Substances and Disease Registry; OMOE = Ontario Ministry of the Environment; $PM_{2.5}$ = particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller; µg/m^3 = micrograms per cubic metre.

Table 5.1-37 Further Analysis of Nickel and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Comparison of maximum, 95th, and 75th percentile concentrations to acute limits	• **Construction Case:** The maximum predicted 24-hour concentration at the MPOI for the Construction Case, as well as 75th and 95th percentile concentrations, did not exceed the acute exposure limit. • **Application Case:** The maximum predicted 24-hour concentration at the MPOI (0.15 µg/m^3) exceeded the acute exposure limit of 0.1 µg/m^3. The 75th and 95th percentile did not exceed the acute exposure limit. The Project Contribution (Operations Only) concentrations were similar to the Application Case concentrations, with maximum concentrations exceeding the acute exposure limit and 75th and 95th percentile concentrations not exceeding the acute exposure limit.
Comparison of Construction Case and Application Case HQs to Base Case	• At the MPOI, the HQ for the Base Case was 0.23 and increased to 0.63 for the Construction Case and 1.5 for the Application Case. The Project Contribution (Construction Case) HQ was 0.63 and the Project Contribution (Operations Only) HQ was 1.5 at the MPOI.
Frequency of exceedances	• There were no exceedances of the threshold for the Construction Case. • There were five daily exceedances of the threshold at the MPOI for the Application Case, based on a year of modelling.
Conservatism and uncertainty in air predictions	• Road dust, crushing, screening, and conveying of ore and waste rock are the primary emission sources for nickel. The sources of air emissions for the Project were assumed to operate at their maximum daily design capacity at the same time, on all days of the year. In reality, some of the emission sources will not be operational on all days. Air quality modelling was conducted using data for the year 2022, which was expected to be the year with maximum emission rates from the Project.

Table 5.1-37 Further Analysis of Nickel and Determination of Magnitude of Risk (Acute 24-Hour Assessment)

Analysis Criteria	Discussion
Conservatism in the 24-hour threshold for nickel	• The OMOE threshold for nickel as a metal/parameter in PM_{10} is based on carcinogenic and non-carcinogenic effects (supporting documentation available). The 24-hour screening value was derived from the annual screening value (0.02 µg/m^3) and a conversion factor of 5, which is based on empirical monitoring data, ratios of concentrations observed for different averaging times, and meteorological considerations.
Potential acute health effects of nickel	• Acute inhalation exposure may cause respiratory effects. According to ATSDR's review of the inhalation toxicity of nickel, human studies are limited to occupational exposures, with the majority focusing on chronic durations and a cancer endpoint (ATSDR 2005). The two studies reviewed on non-cancer endpoints are not reliable, as workers were exposed to other metals at the same time, making it difficult to determine if the effects were solely related to nickel exposure. NTP (1996b, 1996c; as cited in ATSDR 2005) reported chronic inflammation in rats exposed to 700 µg nickel/m^3 as nickel sulphate and 440 µg nickel/m^3 as nickel subsulphide for 6 hours/day for 12 days. Exposure to 700 µg nickel/m^3 as nickel sulphate and 3,650 µg nickel/m^3 as nickel subsulphide resulted in decreased body weights in rats. The authors also reported that following acute or intermediate exposure, nickel toxicity is related to its solubility, with soluble nickel sulfate being the most toxic and insoluble nickel oxide being the least toxic (NTP 1996b, 1996c; as cited in ATSDR 2005).
Magnitude of risk	• Only the maximum predicted concentration for the Application Case at the MPOI exceeded the acute threshold, primarily a result of the Project contribution. The 95th and 75th percentile concentrations, as well as the Construction Case concentrations, did not exceed the threshold. There were up to five daily exceedances of the threshold at the MPOI. There is a low likelihood of a receptor being present at the MPOI. The magnitude of risk for nickel is considered negligible at all the locations evaluated.

MPOI = maximum point of impingement; HQ = hazard quotient; ATSDR = Agency for Toxic Substances and Disease Registry; NTP = National Toxicology Program; OMOE = Ontario Ministry of the Environment; PM_{10} = particulate matter with a mean aerodynamic diameter of 10 microns or smaller; µg/m^3 = micrograms per cubic metre.

5.1.3 Chronic Inhalation Assessment

Summary of Incremental Lifetime Cancer Risks

Incremental lifetime cancer risks (ILCRs) were calculated for parameters identified as COPCs in the chronic assessment by comparing the concentration predicted for each location (lifetime additive approach [i.e., composite receptor] for seasonal users) with toxicity benchmarks for the Base Case, Construction Case, and Application Case.

Chromium was the only COPC identified for the chronic air assessment. Chromium was identified as a COPC at Diavik Camp, the Ekati Camp/Admin, and the Misery Camp. The ILCR values calculated for the Base Case, Construction Case, and Application Case are presented in Table 5.1-40.

Table 5.1-38 Incremental Lifetime Cancer Risks for Maximum Chronic Predicted Chromium Concentrations

Receptor Location	Incremental Lifetime Cancer Risk - Chromium					
	Construction Case			Application Case		
	Base Case	Construction Case	Project Contribution (Construction Only)	Base Case	Application Case	Project Contribution (Operations Only)
Courageous Lake Lodge	3.2E-08	4.4E-08	1.2E-08	3.2E-08	3.3E-08	6.4E-09
Diavik Camp	**<u>7.2E-05</u>**	**<u>7.3E-05</u>**	8.1E-07	**<u>7.2E-05</u>**	**<u>7.3E-05</u>**	1.9E-07
Diavik TK Camp	2.3E-06	3.1E-06	8.2E-07	2.3E-06	2.7E-06	3.6E-07
Ekati Camp/Admin	**<u>9.8E-05</u>**	**<u>9.8E-05</u>**	3.0E-07	**<u>9.8E-05</u>**	**<u>7.5E-05</u>**	-2.3E-05
Lac de Gras Winter Road Rest Stop	8.6E-07	1.1E-06	2.6E-07	8.6E-07	1.0E-06	1.8E-07
LDG Hunting Camp	8.5E-07	1.7E-06	8.3E-07	8.5E-07	1.4E-06	5.1E-07
Misery Camp	**<u>5.3E-05</u>**	**<u>8.6E-05</u>**	**<u>3.2E-05</u>**	**<u>5.3E-05</u>**	**<u>2.3E-05</u>**	-3.0E-05
Pellatt Lake Cabin	5.0E-08	7.0E-08	2.1E-08	5.0E-08	5.5E-08	8.9E-09
Salmita Airstrip	3.7E-08	4.8E-08	1.1E-08	3.7E-08	4.4E-08	4.6E-09
Treeline Lodge	3.7E-08	4.7E-08	1.0E-08	3.7E-08	4.4E-08	3.9E-09

Note: **<u>Bold and underlined</u>** values exceed an incremental lifetime cancer risk of $1x10^{-5}$.

LDG = Lac de Gras; TK = Traditional Knowledge.

For both the Construction and Application Cases, ILCRs for chromium were greater than $1x10^{-5}$ at Diavik Camp, Ekati Camp/Admin, and Misery Camp. For the Project Contribution from the Construction Case, the ILCR for chromium was greater than $1x10^{-5}$ at Misery Camp. Further analysis of these parameters is provided in Section 5.1.2.1.

There were two incidences where the Project Contribution from the Application Case was negative. The Base Case is calculated from the operations of Ekati (and Misery) and Diavik mines. During the Application Case, however, the operations of Ekati are focused on the Jay pit, and a number of the Base Case pits and fleet allocations change as a result of the closure of some of the existing Ekati mining pits. The change in mining operations results in some receptor locations having lower concentrations/depositions in the Application and Construction Cases than the Base Case.

5.1.3.1 Further Analysis of Chromium

For locations where ILCR values were greater than $1x10^{-5}$ for the Construction Case or Application Case, a magnitude of risk assessment was completed. Results of the assessment for the chronic air quality assessment are presented in Table 5.1-41.

Table 5.1-39 Further Analysis of Chromium (VI) and Determination of Magnitude of Risk (Chronic Assessment)

Analysis Criteria	Discussion
Comparison of Construction Case and Application Case ILCRs to Base Case	• At the Diavik Camp, the ILCR was $7.2x10^{-5}$ for the Base Case and $7.3x10^{-5}$ for both the Construction Case and Application Case. The Project Contribution (Construction Case) and Project Contribution (Application Case) ILCRs were $8.1x10^{-7}$ and $1.9x10^{-7}$, respectively, at the Diavik Camp. • At the Ekati Camp/Admin, the ILCR was $9.8x10^{-5}$ for both the Base Case and Construction Case and $7.5x10^{-5}$ for the Application Case. The Project Contribution (Construction Case) and Project Contribution (Application Case) ILCRs were $3.0x10^{-7}$ and $-2.3x10^{-5}$, respectively, at the Ekati Camp/Admin. • At the Misery Camp, the ILCR was $5.3x10^{-5}$ for the Base Case, $8.6x10^{-5}$ for the Construction Case, and $2.3x10^{-5}$ for the Application Case. The Project Contribution (Construction Case) and Project Contribution (Application Case) ILCRs were $3.2x10^{-5}$ and $-3.0x10^{-5}$, respectively, at the Misery Camp.
Conservatism and uncertainty in air predictions	• No information was available on the speciation of chromium in the air modelling; as such, it was conservatively assumed that 100% of the chromium was present as chromium (VI). However, it has been estimated that approximately one-third of the atmospheric releases of chromium are in the chromium (VI) form (ATSDR 2012c). In the atmosphere, chromium (VI) may be reduced to chromium (III), with an estimated half-life of 16 hours to 5 days (ATSDR 2012c). Thus, it is considered that the proportion of chromium (VI) present in ambient air is likely to be less than 50%, with the percentage potentially dropping as reduction to chromium (III) in the atmosphere occurs each day.
Conservatism in the chronic threshold for chromium	• A toxicity reference value (TRV) of 0.076 per $\mu g/m^3$ from Health Canada was selected for use in the chronic inhalation assessment. The TRV is based on excess respiratory and nasal cancer incidence in chromate production workers exposed to trivalent and hexavalent chromium (Health Canada 1994). An increase in lung cancer mortality from exposure to total chromium was reported (Mancuso 1975; as cited in Health Canada 1994). Mancuso reported over 50% lung cancer mortality in 332 workers employed from 1931 to 1951. Workers were exposed to insoluble trivalent, soluble hexavalent, and total chromium. It should be noted that the form of chromium responsible for lung cancer is uncertain. This TRV is considered conservative because it is based on a human study.

Table 5.1-39 Further Analysis of Chromium (VI) and Determination of Magnitude of Risk (Chronic Assessment)

Analysis Criteria	Discussion
Potential chronic health effects of chromium	• Several occupational exposure studies have indicated that chronic chromium inhalation is associated with a variety of non-carcinogenic effects including respiratory effects, including upper respiratory problems and nasal septum perforation. Occupationally exposed workers experienced excessive sneezing, runny nose, nosebleeds, ulcerations, and/or perforations when exposed to 0.0001 to 0.0071 mg chromium VI/m^3 for an average of 26.9 months (Cohen et al. 1974; as cited in ATSDR 2012c). Similar symptoms were exhibited in another study by Lucas and Kramkowski (1975; as cited in ATSDR 2012c), where workers were exposed to a mean concentration of 0.004 mg chromium VI/m^3 for an average of 7.5 years. Chromium (VI) is classified as a human carcinogen (Health Canada 2010b; US EPA 1998). A study by Mancuso (1975; as cited in US EPA 1998) reported increased lung cancer incidence and mortality in chromate industry workers exposed to insoluble trivalent, soluble hexavalent, and total chromium between 1931 and 1951. It should be noted that the form of chromium responsible for lung cancer is uncertain.
Magnitude of risk	• ILCRs for chromium are greater than the target cancer risk of $1x10^{-5}$ for the Construction Case and Application Case at the Diavik Camp, the Ekati Camp/Admin, and the Misery Camp. However, the Project Contribution (Construction Only) and Project Contribution (Operations Only) ILCRs are less than the target cancer risk. In addition, the assumption that 100% of the chromium is present is chromium (VI) is expected to be an overestimate, with the proportion of chromium (VI) likely to be less than 50%. Overall, the magnitude of risk for chromium is considered to be low at the three worker camps (Diavik Camp, Ekati Camp/Admin, and Misery Camp). The magnitude of risk for chromium is considered to be negligible at all the other locations evaluated (i.e., recreational locations).

ATSDR = Agency for Toxic Substances and Disease Registry; ILCR = incremental lifetime cancer risk; MPOI = maximum point of impingement.

5.1.4 Particulate Matter

The particulate matter assessment evaluated the potential health effects resulting from inhalation exposure to $PM_{2.5}$ and PM_{10} in air emissions from the Project. The results of a literature review on the health effects of exposure to particulate matter are provided in Appendix G. A discussion of the particulate matter results predicted for the Jay Project is presented below. Results are presented for the Construction Case versus Base Case, as well as for the Application Case versus Base Case. Additional information is provided on the particulate matter concentrations predicted to result from only the Project emissions (Project Contribution [Operations Only]) as well as those predicted for the construction period (Project Contribution [Construction Only]) (i.e., without baseline incorporated).

5.1.4.1 PM_{10}

A 1-hour acute threshold for PM_{10} was not available. The 24-hour PM_{10} predictions and air quality threshold were used to assess acute effects from PM_{10}. In addition, acute effects of PM_{10} are discussed further in the qualitative literature review provided in Appendix G.

The 24-hour PM_{10} concentrations for the Base, Application, and Construction Cases are presented below in Tables 5.1-42 and 5.1-43. Each table also includes the predictions resulting from the Project Contribution [Operations Only] or Project Contribution [Construction Only] phases of the Project (i.e., without background incorporated).

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Predicted maximum, 95th and 75th percentile 24-hour PM_{10} concentrations were compared to the most conservative of the available health-based thresholds (50 µg/m^3, WHO 2006). The WHO guideline is based on the relationship between 24-hr means and annual particulate matter levels. The level has been set based on a number of studies that suggest there is an increase in mortality of approximately 0.5% for every 10 µg/m^3 increment in 24-hr concentration. The guideline is therefore intended to act as an acceptable risk level as opposed to being fully protective of negative health outcomes.

Predicted maximum 24-hour concentrations for the Base, Application, and Construction Cases are below the WHO guideline at the receptor locations assessed with the exception of Diavik Camp, Misery Camp, and the MPOI. The maximum prediction occurs at the MPOI in each Case (579.3 µg/m^3, 1,536.8 µg/m^3 and 1,846.4 µg/m^3, for the Base, Application, and Construction Cases, respectively). Exceedances of the guideline are predicted to occur at the MPOI 167 times in a year for the Base Case, 220 times per year in the Application Case, and 317 times per year in the Construction Case. For the Diavik Camp, exceedances of the threshold are only predicted to occur for one day of the year while at the Misery Camp, exceedances are predicted to occur 11 times per year in the Base Case, once in a year for the Application Case, and 20 times per year for the Construction Case. The predicted 95th percentile concentrations are also below the WHO guideline at all the receptor locations assessed for the Base, Application, and Construction Cases with the exception of the MPOI for all Cases (253.2, 847.8, and 1,242.2 µg/m^3, respectively) and the Misery Camp for the Construction Cases (50.2 µg/m^3). The 75th percentile predictions were below the WHO threshold at all the receptor locations assessed in the Base, Application, and Construction Cases except at the MPOI for all Cases (103.1, 214.9, and 366.0 µg/m^3, respectively).

When considering the contribution of PM_{10} resulting from the Project Contribution [Operations Only], concentrations (i.e., without incorporating background) are similar or reduced from the Application Case. Maximum predicted concentrations for the Project contribution (operations only) still exceed at the MPOI (1,536.1 µg/m^3) and at Misery Camp (74.0 µg/m^3). The 95th and 75th percentiles were below the WHO threshold at the locations assessed with the exception of the MPOI (845.9 and 214.9 µg/m^3, respectively).

Similarly, when considering the contribution of PM_{10} resulting from the Project Contribution [Construction Only] (i.e., without incorporating background), concentrations are similar or reduced from the Construction Case which includes background concentrations. Maximum predicted concentrations for the Project contribution (construction only) still exceed at the MPOI (1,841.7 µg/m^3) and at Misery Camp (68.8 µg/m^3). The 95th and 75th percentiles were below the WHO threshold at the locations assessed with the exception of the MPOI (1,234.9 and 361.7 µg/m^3, respectively).

Further discussion within the context of the literature review results for acute particulate matter effects is provided below in Section 5.1.4.5.

Thresholds for 24-hr PM_{10} concentrations are also available from Ontario Ministry of Environment (OMOE) and the US National Ambient Air Quality Standards (US NAAQS; see Appendix N.1-3, Table 1). The OMOE 24-hour PM_{10} threshold of 50 µg/m^3 is equivalent to the WHO guideline chosen for this assessment while the US NAAQS standard of 150 µg/m^3 is above the WHO guideline value used in this assessment. The potential health effects of PM_{10} are discussed further in the qualitative literature review (Appendix G).

Annual maximum concentrations of PM_{10} were compared to the most conservative of the available health-based thresholds (20 µg/m^3, WHO 2006). The maximum predicted annual concentrations were below the WHO guideline for the receptor locations assessed in each of the Cases. As predicted annual PM_{10} concentrations did not exceed the most conservative health-based threshold, these PM_{10} concentrations were not evaluated further.

Table 5.1-40 Comparison of Predicted 24-hour Maximum, 75th, and 95th Percentile Concentrations of PM_{10} for the Base and Application Case with the WHO Guideline

Location	Base Case				Application Case				Project Contribution [Operations Only]			
	Maximum Concentration [µg/m³]	95th Percentile Concentration [µg/m³]	75th Percentile Concentration [µg/m³]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)	Maximum Concentration [µg/m³]	95th Percentile Concentration [µg/m³]	75th Percentile Concentration [µg/m³]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)	Maximum Concentration [µg/m³]	95th Percentile Concentration [µg/m³]	75th Percentile Concentration [µg/m³]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)
Courageous Lake Lodge	3.0	2.8	2.7	0	3.2	2.9	2.7	0	2.9	2.7	2.7	0
Diavik Camp	**51.6**	18.2	10.1	1	**51.5**	18.0	10.2	1	6.7	3.1	2.7	0
Diavik TK Camp	16.1	5.9	4.0	0	14.9	6.7	4.2	0	10.8	4.8	2.7	0
Ekati Camp/Admin	42.6	19.2	10.1	0	23.4	12.7	7.3	0	4.8	3.0	2.7	0
Lac de Gras Winter Road Rest Stop	5.3	4.0	3.2	0	7.1	4.4	3.3	0	6.4	3.4	2.7	0
LDG Hunting Camp	9.5	4.9	3.3	0	13.7	5.7	3.6	0	13.5	5.1	2.9	0
Misery Camp	**130.0**	38.2	14.4	11	**74.3**	17.7	7.4	1	**74.0**	13.3	4.5	1
Pellatt Lake Cabin	3.2	2.9	2.7	0	3.8	3.0	2.7	0	3.4	2.8	2.7	0
Salmita Airstrip	3.2	2.8	2.7	0	3.4	2.8	2.7	0	2.9	2.7	2.7	0
Treeline Lodge	3.2	2.8	2.7	0	3.4	2.9	2.7	0	2.9	2.7	2.7	0
MPOI	**579.3**	**253.2**	**103.1**	167	**1536.8**	**847.8**	**214.9**	220	**1536.1**	**845.9**	**214.9**	220
WHO [(a)]	**50**											

a) WHO 2006.

Note: **Bold and underlined** values indicate an exceedance of the WHO air quality guideline.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; PM_{10} = particulate matter with a mean aerodynamic diameter of 10 microns or smaller; WHO = World Health Organization; TK = Traditional Knowledge.

Table 5.1-41 Comparison of Predicted 24-hour maximum, 75th and 95th percentile concentrations of PM_{10} for the Base and Construction Case with the WHO Guideline

Location	Base Case				Construction Case				Project Contribution [Construction Only]			
	Maximum Concentration [μg/m^3]	95th Percentile Concentration [μg/m^3]	75th Percentile Concentration [μg/m^3]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)	Maximum Concentration [μg/m^3]	95th Percentile Concentration [μg/m^3]	75th Percentile Concentration [μg/m^3]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)	Maximum Concentration [μg/m3]	95th Percentile Concentration [μg/m^3]	75th Percentile Concentration [μg/m^3]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)
Courageous Lake Lodge	3.0	2.8	2.7	0	3.3	2.9	2.7	0	0.3	0.1	0.0	0
Diavik Camp	**51.6**	18.2	10.1	1	**51.6**	18.2	10.6	1	7.7	1.3	0.1	0
Diavik TK Camp	16.1	5.9	4.0	0	20.1	7.4	4.7	0	9.6	2.5	0.3	0
Ekati Camp/Admin	42.6	19.2	10.1	0	42.6	19.2	10.2	0	2.9	0.6	0.0	0
Lac de Gras Winter Road Rest Stop	5.3	4.0	3.2	0	8.3	4.7	3.5	0	3.3	0.9	0.1	0
LDG Hunting Camp	9.5	4.9	3.3	0	11.1	6.4	4.1	0	6.5	2.3	0.5	0
Misery Camp	**130.0**	38.2	14.4	11	**140.5**	**50.2**	20.4	20	**68.8**	17.6	6.2	3
Pellatt Lake Cabin	3.2	2.9	2.7	0	4.0	3.0	2.7	0	0.8	0.1	0.0	0
Salmita Airstrip	3.2	2.8	2.7	0	3.5	2.9	2.7	0	0.3	0.1	0.0	0
Treeline Lodge	3.2	2.8	2.7	0	3.5	2.9	2.7	0	0.3	0.1	0.0	0
MPOI	**579.3**	**253.2**	**103.1**	167	**1,846.4**	**1,242.2**	**366.0**	317	**1,841.7**	**1,234.9**	**361.7**	316
WHO [(a)]	**50**											

a) WHO 2006.

Note: **Bold and underlined** values indicate an exceedance of the WHO air quality guideline.

MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; PM_{10} = particulate matter with a mean aerodynamic diameter of 10 microns or smaller; WHO = World Health Organization; TK = Traditional Knowledge.

5.1.4.2 PM2.5

A 1-hour acute threshold for $PM_{2.5}$ was not available. The 24-hr predictions for $PM_{2.5}$, which are discussed further below, are used to assess the acute affects associated with $PM_{2.5}$ in the absence of a 1-hr threshold. In addition, a qualitative discussion on the effects of acute exposure to $PM_{2.5}$ is provided in Appendix G.

The 24-hr $PM_{2.5}$ concentrations for the Base, Application, and Construction Cases are presented below in Tables 5.1-44 and 5.1-45. Each table also includes the predictions resulting from the Project Contribution [Operations Only] or Project Contribution [Construction Only] (i.e., without Base Case incorporated).

Predicted maximum, 95^{th}, and 75^{th} percentile 24-hr $PM_{2.5}$ concentrations were compared to the most conservative of the available health-based thresholds (25 $\mu g/m^3$, WHO 2006). The guideline is based on the same toxicological endpoint as PM_{10} where exposure is associated with approximately a 0.5% increase in mortality per 10 $\mu g/m^3$ increase in PM_{10}. The PM_{10} guideline is converted using a $PM_{2.5}$:PM_{10} ratio of 0.5. This $PM_{2.5}$:PM_{10} ratio is typical of that found in urban areas of developing countries. In these areas, $PM_{2.5}$:PM_{10} ratios have been found to range from 0.5 to 0.8, and therefore, the bottom end of the range was chosen for the conversion (WHO 2006).

For the Base Case, the maximum concentration of $PM_{2.5}$ is less than the WHO guideline (25 $\mu g/m^3$) at all the receptor locations assessed with the exception of the Diavik Camp (30.9 $\mu g/m^3$) and the MPOI (93.7 $\mu g/m^3$). Exceedances are predicted to occur for 29 days per year at the MPOI and for 2 days at the Diavik Camp. The 95^{th} and 75^{th} percentiles for the Base Case are below the WHO guideline at all the receptor locations assessed with the exception the 95^{th} percentile at the MPOI (34.5 $\mu g/m^3$). For the Application Case, the maximum $PM_{2.5}$ concentrations are below the WHO guideline at the receptor locations with the exception of the Diavik Camp (31.0 $\mu g/m^3$) and the MPOI (322.3 $\mu g/m^3$). In the Application Case, exceedances are predicted to occur 2 days out of a year at the Diavik Camp and for 158 days out of a year at the MPOI. The 95^{th} and 75^{th} percentiles also exceeded the WHO guideline at the MPOI (158.3 and 48.6 $\mu g/m^3$, respectively). In the Construction Case, the maximum concentration exceeds the WHO guideline at the Diavik Camp (31.0 $\mu g/m^3$), at the Misery Camp (27.5 $\mu g/m^3$), and at the MPOI (281.7 $\mu g/m^3$). Exceedances are predicted to occur for 2 days out of the year at the Diavik Camp, once in a year for the Misery Camp, and for 146 days out of the year at the MPOI. The 95^{th} and 75^{th} percentiles are less than the WHO guideline for the receptor locations assessed except the MPOI (168.6 and 50.9 $\mu g/m^3$, respectively).

For the Project Contribution [Operations Only], predictions were similar or reduced from the Application Case. The maximum, 95^{th} and 75^{th} percentiles are below the threshold at the receptor locations assessed except at the MPOI (321.6, 157.3, and 48.2 $\mu g/m^3$).

With respect to the contribution resulting from the Project Contribution [Operations Only] (i.e., without a Base Case contribution), predictions were similar or reduced from the Construction Case. The maximum, 95^{th} and 75^{th} percentiles are below the threshold at the receptor locations assessed except the MPOI (321.6, 157.3, and 48.2 $\mu g/m^3$). Further discussion within the context of the literature review results for acute particulate matter effects is provided below in Section 5.1.4.5.

Thresholds for the 24-hr $PM_{2.5}$ concentrations are also available from Northwest Territories, Canadian Council of Ministers for the Environment (CCME), US NAAQS, and the OMOE (see Appendix N.1-3, Table X). The Northwest Territories value of 28 µg/m^3 was adapted from the CCME, and although locally relevant, is not as conservative as the WHO guideline. Therefore, the WHO guideline of 25 µg/m^3 was chosen for this assessment. The potential effects of $PM_{2.5}$ are discussed further in the qualitative literature review (Appendix G).

Annual maximum concentrations of $PM_{2.5}$ were compared to the most conservative of the available health-based thresholds (10 µg/m^3, WHO, Northwest Territories, and CCME). The maximum annual concentrations are below these guidelines for all the receptor locations assessed in each of the Cases. Therefore, annual $PM_{2.5}$ concentrations were not evaluated further.

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Table 5.1-42 Comparison of Predicted 24-hour Maximum, 75th and 95th Percentile Concentrations of $PM_{2.5}$ for the Base and Application Case with the WHO Guideline

Location	Base Case				Application Case				Project Contribution [Operations Only]			
	Maximum Concentration [µg/m³]	95th Percentile Concentration [µg/m³]	75th Percentile Concentration [µg/m³]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)	Maximum Concentration [µg/m³]	95th Percentile Concentration [µg/m³]	75th Percentile Concentration [µg/m³]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)	Maximum Concentration [µg/m3]	95th Percentile Concentration [µg/m³]	75th Percentile Concentration [µg/m³]	Frequency of Exceedances (Number of 24-hour Exceedances in a Year)
Courageous Lake Lodge	2.3	2.0	1.9	0	2.3	2.1	1.9	0	2.0	1.9	1.9	0
Diavik Camp	**30.9**	14.6	6.7	2	**31.0**	14.6	6.9	2	3.8	2.2	1.9	0
Diavik TK Camp	10.2	4.8	2.8	0	10.5	4.9	3.0	0	4.4	2.6	2.0	0
Ekati Camp/Admin	9.2	5.7	3.6	0	7.7	4.6	3.2	0	2.6	2.1	1.9	0
Lac de Gras Winter Road Rest Stop	5.0	3.2	2.3	0	5.0	3.4	2.4	0	3.1	2.2	1.9	0
LDG Hunting Camp	7.8	3.0	2.2	0	8.7	3.5	2.5	0	8.3	2.8	2.1	0
Misery Camp	25.0	8.1	4.1	0	20.6	7.9	3.8	0	20.6	5.2	2.5	0
Pellatt Lake Cabin	2.7	2.0	1.9	0	2.8	2.1	1.9	0	2.1	2.0	1.9	0
Salmita Airstrip	2.6	2.0	1.9	0	2.7	2.1	1.9	0	2.0	1.9	1.9	0
Treeline Lodge	2.6	2.1	1.9	0	2.7	2.1	1.9	0	2.0	1.9	1.9	0
MPOI	**93.7**	**34.5**	11.7	29	**322.3**	**158.3**	**48.6**	158	**321.6**	**157.3**	**48.2**	156
WHO [(a)]	**25**											

a) WHO 2006.

Note: **Bold and underlined** values indicate an exceedance of the WHO air quality guideline.

$PM_{2.5}$ = particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller; MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; WHO = World Health Organization; TK = Traditional Knowledge.

Table 5.1-43 Comparison of Predicted 24-hour Maximum, 75th and 95th Percentile Concentrations of $PM_{2.5}$ for the Base and Construction Case with the WHO Guideline

	Base Case				Construction Case				Project Contribution [Construction Only]			
Location	**Maximum Concentration [µg/m³]**	**95th Percentile Concentration [µg/m³]**	**75th Percentile Concentration [µg/m³]**	**Frequency of Exceedances (Number of 24-hour Exceedances in a Year)**	**Maximum Concentration [µg/m³]**	**95th Percentile Concentration [µg/m³]**	**75th Percentile Concentration [µg/m³]**	**Frequency of Exceedances (Number of 24-hour Exceedances in a Year)**	**Maximum Concentration [µg/m³]**	**95th Percentile Concentration [µg/m³]**	**75th Percentile Concentration [µg/m³]**	**Frequency of Exceedances (Number of 24-hour Exceedances in a Year)**
Courageous Lake Lodge	2.3	2.0	1.9	0	2.3	2.1	1.9	0	2.0	1.9	1.9	0
Diavik Camp	**<u>30.9</u>**	14.6	6.7	2	**<u>31.0</u>**	14.7	6.9	2	3.6	2.2	1.9	0
Diavik TK Camp	10.2	4.8	2.8	0	11.2	4.9	3.0	0	4.1	2.4	2.0	0
Ekati Camp/Admin	9.2	5.7	3.6	0	9.2	5.7	3.6	0	2.5	2.0	1.9	0
Lac de Gras Winter Road Rest Stop	5.0	3.2	2.3	0	5.0	3.3	2.3	0	2.8	2.1	1.9	0
LDG Hunting Camp	7.8	3.0	2.2	0	8.1	3.3	2.4	0	5.0	2.4	2.1	0
Misery Camp	25.0	8.1	4.1	0	**<u>27.5</u>**	12.0	5.4	1	14.5	5.9	3.0	0
Pellatt Lake Cabin	2.7	2.0	1.9	0	2.7	2.1	1.9	0	2.0	1.9	1.9	0
Salmita Airstrip	2.6	2.0	1.9	0	2.7	2.1	1.9	0	2.0	1.9	1.9	0
Treeline Lodge	2.6	2.1	1.9	0	2.6	2.1	1.9	0	2.0	1.9	1.9	0
MPOI	**<u>93.7</u>**	**<u>34.5</u>**	11.7	29	**<u>281.7</u>**	**<u>168.6</u>**	**<u>50.9</u>**	146	**<u>280.9</u>**	**<u>168.3</u>**	**<u>50.3</u>**	152
WHO [(a)]	**25**											

a) WHO 2006.

Note: **<u>Bold and underlined</u>** values indicate an exceedance of the WHO air quality guideline.

$PM_{2.5}$ = particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller; MPOI = maximum point of impingement (i.e., maximum concentration outside the mine site); LDG = Lac de Gras; WHO = World Health Organization; TK = Traditional Knowledge.

5.1.4.3 Background Concentrations in Surrounding Areas

Information on background concentrations is provided in the Air Quality Assessment (DAR Section 7) and in the Supplemental Air Quality Memo (Golder 2015a). Subsections from these reports, which are relevant to the particulate matter assessment, are summarized in this section. $PM_{2.5}$ measurements were collected between 2003 and 2008, while PM_{10} measurements were collected in 2002. The most appropriate natural background $PM_{2.5}$ and PM_{10} concentrations in the region are measurements from NWT Tundra Ecological Research Station located at Daring Lake. However, the PM_{10} measurements collected at this station in 2002 were not used, as the measured PM_{10} concentration values in 2002 are lower than the measured $PM_{2.5}$ concentration values between 2003 and 2008. $PM_{2.5}$ is a subset of PM_{10}, and therefore, background PM_{10} concentrations should be higher than background $PM_{2.5}$ concentrations. A rural PM_{10}/$PM_{2.5}$ ratio of 1.5 (Brook et al. 1997) was applied to the $PM_{2.5}$ median concentration measured between 2003 and 2007. The background PM_{10} concentration calculated using this method is 2.7 µg/m^3.Additional information on background concentrations of $PM_{2.5}$ and PM_{10} incorporated into the Base Case are provided in the Air Quality Assessment (DAR Section 7) and the Supplemental Air Quality Memo (Golder 2015a).

Existing air quality in the area of the Project is likely to be influenced by dust generated from use of unpaved roads, forest fires, and existing mining projects already in operation.

5.1.4.4 Conservatism in the Acute and Chronic Thresholds

PM_{10}

The most conservative health-based threshold for PM_{10} (24-hr) used in this assessment was a WHO guideline (50 µg/m^3, WHO 2006). The WHO guideline is based on the relationship between 24-hr mean and annual particulate matter levels. The level has been set based on a number of studies that suggest there is an increase in mortality of approximately 0.5% for every 10 µg/m^3 increment in 24-hr concentration. The guideline is, therefore, intended to act as an acceptable risk level as opposed to being fully protective of negative health outcomes. The conservatism incorporated into the guideline is unknown, as it is based on a variety of epidemiological study results.

$PM_{2.5}$

The most conservative health-based threshold for $PM_{2.5}$ (24-hr) used in this assessment was 25 µg/m^3, from the WHO (2006). The guideline is based on the same toxicological endpoint as PM_{10} where exposure is associated with approximately a 0.5% increase in mortality per 10 µg/m^3 increase in PM_{10}. The PM_{10} guideline is converted using a $PM_{2.5}$:PM_{10} ratio of 0.5. This $PM_{2.5}$:PM_{10} ratio is typical of that found in urban areas of developing countries and is at the bottom of the range found in urban areas in developed countries (0.5 to 0.8) (WHO 2006). The conservatism incorporated into the guideline is unknown, as it is based on a variety of epidemiological study results.

5.1.4.5 Conclusions of the Literature Review and Particulate Matter Assessment

Potential health effects of particulate matter concentration changes as a result of the Project were assessed qualitatively by a review of key epidemiological studies focused on health effects associated with particulate matter.

Overall, uncertainty remains in evaluating the predicted particulate matter concentrations, as particulate matter guidelines are based on epidemiological studies, which include confounding factors that can affect the results. In addition, the literature suggests that no threshold exists for particulate matter and that health effects are present at background levels of particulate matter in some countries. The 24-hr PM_{10} and $PM_{2.5}$ maximum, 95^{th}, and 75^{th} percentile concentrations exceed applicable screening values in the Application and Construction Cases at the MPOI. In addition, maximum concentrations exceed for PM_{10} and $PM_{2.5}$ in either or both the Application and Construction Cases at the Diavik and Misery Camps. It is not anticipated that people will spend much time at the MPOI, as in each case it is located within the Project boundary but away from sensitive receptor locations (see Maps I-16 to I-21, Appendix I). While people are therefore not anticipated to spend much of their time at the MPOI, concentrations of both PM_{10} and $PM_{2.5}$ still exceed health based thresholds at the Diavik and Misery Camps where workers will be living.

Dust from transport related to mining activities (i.e., crustal sources) appears to be the main contributor to particulate matter concentrations predicted for the Project (Appendix A). Epidemiology studies, though not always consistent, suggest that composition of the particulate matter is the most important predictor of health outcomes (Stanek et. al. 2011).

The relationships between health effects and exposure to respirable particulate matter are derived from epidemiology studies based on large urban centres making comparisons to small rural areas challenging. In addition, the database related to health effects from particulate matter relies heavily on studies where the particulates are derived from combustion sources. Few studies were available concerning possible health outcomes from wind-blown dust (i.e., road dust or dust from open pits) – particularly for fine particulates (i.e., $PM_{2.5}$); however, some studies have found adverse health effects. These studies would suggest that health effects are possible if predictions for the Diavik and Misery Camps are accurate.
The magnitude of risk as a result of the Project is uncertain, but expected to be negligible at the receptor locations assessed with the exception of the Diavik Camp, the Misery Camp, and the MPOI because predicted concentrations are well below the most conservative screening values for human health. For the MPOI and the two worker camps where predictions are higher than the screening value, it is expected that the magnitude of risk will be low given the conservatism built into the model predictions.

5.2 Human Health Effects – Multimedia Assessment

The human health risk assessment was carried out as a multimedia assessment, which provides the sum of exposures from ingestion, inhalation, and dermal contact with the environmental media predicted to be affected by the Project (i.e., air, surface water, fish, soil, vegetation, and wild game) and other media that can also contribute to exposure (i.e., sediment and background dietary intake).

Risks related to both cancer and non-cancer endpoints were assessed. For the Seasonal Aboriginal scenario, the non-cancer assessment (i.e., estimation of HQs) was conducted with a focus on the toddler lifestage, because of the increased sensitivity toddlers typically exhibit relative to adults. Non-cancer risks were also calculated for the adult life stage. For the Seasonal non-Aboriginal scenario, non-cancer risks are presented for the teenager and adult receptors, as younger receptors were not expected to be present on commercial hunting and fishing trips. The cancer assessment (i.e., estimation of ILCRs) was conducted for a composite receptor. This composite approach was used to assess risk across the exposed life stages combined over a lifetime (i.e., all life stages for Aboriginal receptors, and the teenage and adult life stages for the non-Aboriginal receptors).

The HQ values generated for Aboriginal and non-Aboriginal Seasonal Users are summarized in Tables 5.2-1 and 5.2-2, respectively. The ILCRs for carcinogenic COPCs (arsenic and chromium) are presented in Table 5.2-3, along with the combined ILCR for the lung cancer effect (sum of the ILCRs for arsenic and chromium via the inhalation pathway). More detailed risk estimates for each receptor and COPC combination for the Application Case are provided in Appendix H (Model Results). Total risk estimates are broken down by contributing pathways in Figure 5.2-1 (HQs for Seasonal Aboriginal toddler) and Figure 5.2-2 (ILCRs for Seasonal Users).

Inorganic mercury and selenium exhibited HQs greater than the threshold of 1.0 for the toddler Aboriginal Seasonal User, whereas HQs for these parameters were below the threshold of 1.0 for the non-Aboriginal Seasonal User. Arsenic exhibited an ILCR greater than the threshold of 10^{-5} for both the Aboriginal and non-Aboriginal Seasonal Users. Risks to arsenic (non-cancer risks), chromium, and methyl mercury were below the threshold risk estimates for all receptors, and risks for the target effect of lung tumours (via inhalation of arsenic and chromium) were also below the threshold. The COPCs and receptor scenarios with HQs greater than 1.0 and ILCRs greater than 10^{-5} were carried forward for further assessment of magnitude of risk (Tables 5.2-4 to 5.2-6). The COPCs with estimated risk levels lower than the thresholds (chromium and inorganic mercury) were considered to have a negligible risk.

Table 5.2-1 Hazard Quotients for Aboriginal Seasonal Users

COPC	Base Case		Application Case		Change as a Result of the Project	
	Toddler	Adult	Toddler	Adult	Toddler	Adult
Arsenic	0.83	0.33	0.85	0.34	0.02	0.01
Chromium	0.76	0.37	0.82	0.40	0.06	0.03
Mercury (inorganic)	**1.0**	0.51	**1.3**	0.62	0.3	0.11
Methyl Mercury	0.52	0.32	0.62	0.38	0.10	0.06
Selenium	0.95	0.40	**1.2**	0.51	0.2	0.11

Note: **Bold and underlined** values exceed a hazard quotient of 1.0.
COPC = constituent of potential concern.

Table 5.2-2 Hazard Quotients for Non-Aboriginal Seasonal Users

COPC	Base Case		Application Case		Change as a Result of the Project	
	Teen	Adult	Teen	Adult	Teen	Adult
Arsenic	0.32	0.31	0.32	0.32	<0.01	0.01
Chromium	0.22	0.24	0.23	0.25	0.01	0.01
Mercury (inorganic)	0.18	0.16	0.22	0.20	0.04	0.04
Methyl Mercury	0.17	0.17	0.19	0.19	0.02	0.02
Selenium	0.33	0.35	0.36	0.38	0.02	0.03

COPC = constituent of potential concern; < = less than.

Table 5.2-3 Incremental Lifetime Cancer Risks (ILCRs) for Seasonal Users

COPC	Seasonal Aboriginals			Seasonal Non-Non-Aboriginals		
	Base Case	Application Case	Change as a result of the Project	Base Case	Application Case	Change as a result of the Project
Arsenic	**1.6×10^{-4}**	**1.7×10^{-4}**	3.2×10^{-6}	**1.1×10^{-4}**	**1.1×10^{-4}**	1.1×10^{-6}
Chromium (inhalation only)	2.5×10^{-6}	2.9×10^{-6}	3.3×10^{-7}	2.2×10^{-6}	2.4×10^{-6}	2.8×10^{-7}
Lung tumours (inhalation only)	2.6×10^{-6}	2.9×10^{-6}	3.3×10^{-7}	2.2×10^{-6}	2.5×10^{-6}	2.8×10^{-7}

Note: **Bold and underlined** values exceed an incremental lifetime cancer risk of 1.0 $\times 10^{-5}$.
COPC = constituent of potential concern.

Figure 5.2-1 Hazard Quotient by Pathway for Toddler Seasonal User (Aboriginals)

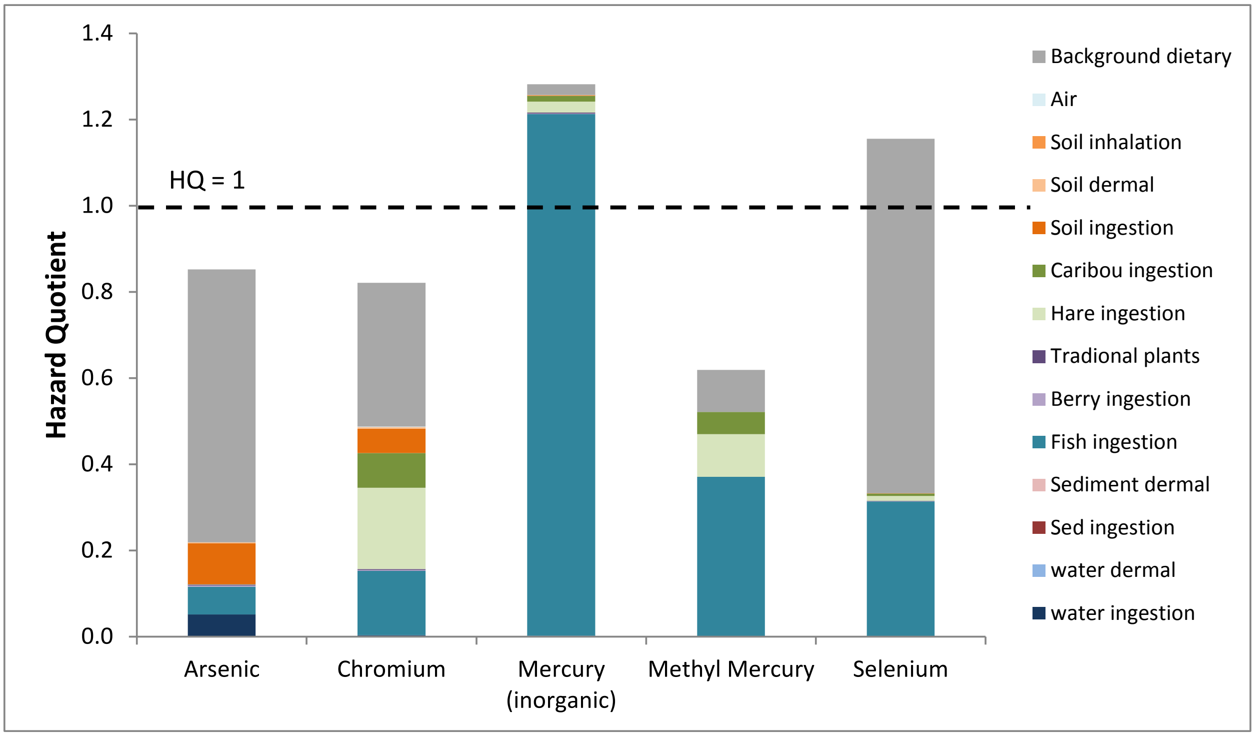
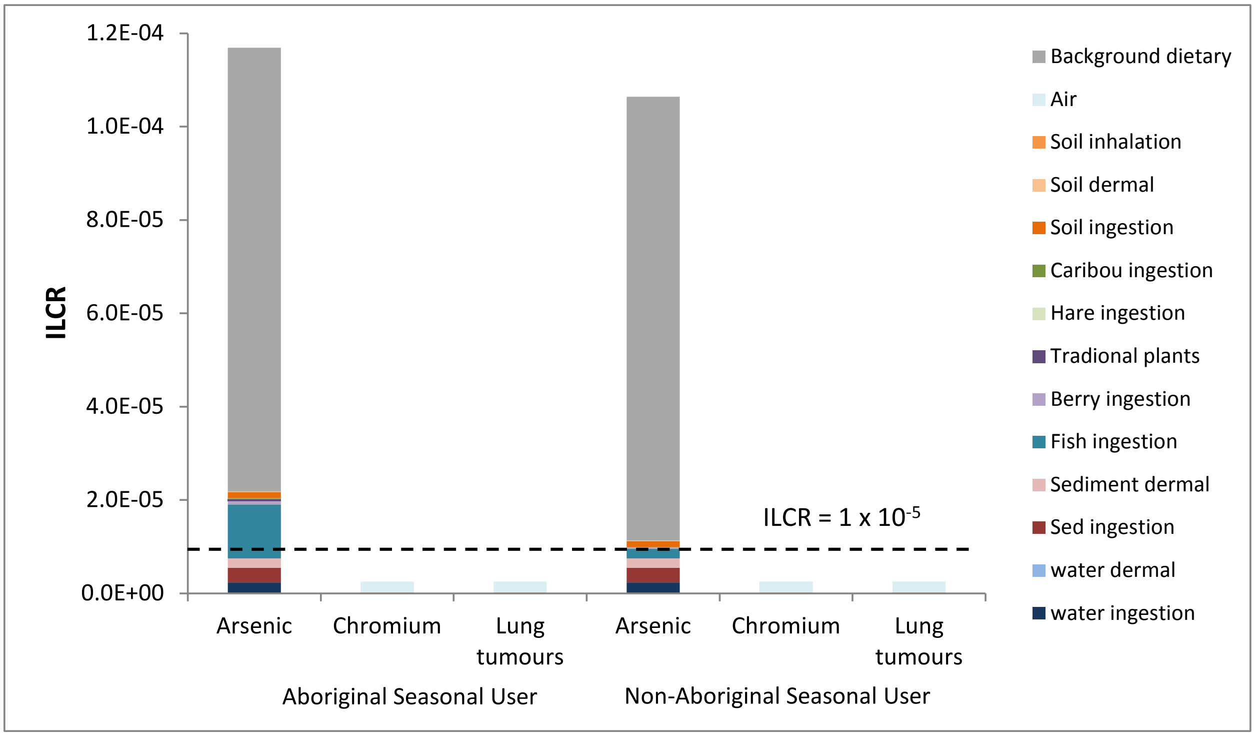


Figure 5.2-2 ILCRs by Pathway for Seasonal Users



The COPCs with HQs greater than 1.0 and ILCR values greater than the threshold of $1x10^{-5}$ were carried forward for further assessment of the magnitude of potential risks to human health (Tables 5.2-4 to 5.2-6).

Table 5.2-4 Further Analysis of Arsenic (Carcinogenic Effects) and Determination of Magnitude of Potential Risk to Human Health

Analysis Criteria	Discussion
Magnitude of predicted risk estimate in the impact case	• Cancer risks for arsenic exceeded the target ILCR of 1×10^{-5} for both the seasonal Aboriginals (ILCR = 1.7×10^{-4}) and non-Aboriginals (ILCR = 1.1×10^{-4}) receptors. The primary contribution to the risk estimates was from background dietary exposure (>80% of total exposure).
Comparison of Base Case to Application Case (change as a result of the Project)	• The increase in ILCR from Base Case to Application Case was minimal, at less than 2%. The Project only contribution (Application Case minus Base Case) was less than the acceptable threshold, with an ILCR of 3.2×10^{-6} (Aboriginal Seasonal User) and 1.1×10^{-6} (non-Aboriginal Seasonal User).
Significant Exposure Pathways	• Background dietary exposure accounted for 81% of total exposure for Aboriginal receptors and 89% of total exposure for non-Aboriginal Seasonal Users. Background dietary exposure information was obtained from a survey of average Canadian consumption patterns and arsenic concentrations in market food items in Toronto (Health Canada 2011), and was adjusted to reflect the fraction of inorganic arsenic in various food products (Schoof et al. 1999). These data may not reflect the actual background dietary exposure in communities near the ESA, given that there is a higher reliance on country foods in this area, and some of the food items associated with the highest arsenic intakes (e.g., rice, which comprised 10% of background intake) may not be consumed to as great an extent in these communities. • The Government of Canada's Priority Substances List Assessment Report on Arsenic (Government of Canada 1993) provides estimates of total daily exposure to inorganic arsenic from environmental sources ranging from 0.1 to 2.6 µg/kg/day, which includes exposure via drinking water. In areas near point sources, exposure may be up to 35 µg/kg/day. These exposures would correspond to ILCRs of $1.5 x10^{-4}$ to $3.9 x10^{-3}$ for the general population, and up to $5.9 x10^{-2}$ in populations near point sources. The estimated ILCRs for the seasonal receptors are at the low end of the range of background exposure for the general Canadian population, and are much lower than the background estimates near point sources. • After background dietary intake, the next most significant pathways were ingestion of fish (10% of total dose for Aboriginals, 2% for non-Aboriginal), and ingestion of sediment (3% of total dose).
Conservatism and uncertainty in predictions	• Several sources of uncertainty in the HHRA relate to the air quality predictions and deposition rates used to predict COPC concentrations in soil and country food items. The air quality and deposition rate predictions use the maximum emission rates from the Project; however, this is a conservative assumption because most equipment does not operate at its maximum capacity on a continuous basis. This assumption can lead to overestimation of the potential Project impacts for the longer averaging periods (24-hour and annual). • Country food predictions are based on soil quality and deposition rates for receptor locations in proximity to the mines (Lac de Gras hunting camp, Diavik TK camp, and Lac de Gras winter road rest stop; Map 1.5-2); therefore, applying these to the entire ESA is considered conservative. The water and fish predictions were based on conservative assumptions. For example, the maximum predicted value across all stations and all operation phases was selected as the exposure concentration for surface water and for predicting fish tissue concentrations.
Conservatism in the exposure assumptions	• The exposure assessment used site-specific chemistry data and exposure intake values for the Northern Aboriginal populations as available. • Although receptors were only assumed to access the ESA seasonally (three months of the year), exposure doses for non-carcinogenic effects were not amortized and a chronic toxicity reference value was used as per Health Canada guidance (Haber and Meek 2013). The exposure assessment assumed that Aboriginals obtained 100% of their game meat, traditional plants, self-picked berries, and fish from the ESA, and that non-Aboriginals obtained 50% of their game meat, berries, and fish from the ESA; however, it is more likely that people hunt, gather, and fish in other areas as well.

Table 5.2-4 Further Analysis of Arsenic (Carcinogenic Effects) and Determination of Magnitude of Potential Risk to Human Health

Analysis Criteria	Discussion
Conservatism in the toxicity reference values used for arsenic	• Given that the primary pathways contributing to the risk estimates were the ingestion food items, the discussion provided below is for TRVs for the oral pathway. • The oral slope factor used in the risk assessment was obtained from Health Canada (1.8 $[mg/kg/day]^{-1}$; Health Canada 2010b). The slope factor was derived based on an epidemiological study where humans were naturally exposed to arsenic in drinking water for up to 60 years. Overall, using a 1% increase in risk, the unit risks associated with ingestion of 1 µg/L of arsenic in drinking water was estimated to range from 3.06×10^{-6} to 3.85×10^{-5}, with 95% upper bounds ranging from 6.49×10^{-6} to 4.64×10^{-5} (Health Canada 2010b). The most sensitive endpoint for both males and females was lung cancer. The overall unit risk associated with the ingestion of arsenic in drinking water was reported as a range, given that lifetime exposure to arsenic results in more than one cancer endpoint in different individuals. The use of a slope factor based on ingestion of drinking water would likely overestimate exposure from ingestion of food items, because arsenic in many food items (e.g., fish) can be predominantly in the less toxic organic forms (ATSDR 2007b).
Potential health effects	• Epidemiological studies used to derive oral slope factors for arsenic are based on observations of cancer of the urinary bladder, lungs, and skin in communities exposed to high concentrations of arsenic.
Magnitude of risk	• For seasonal users (Aboriginal and non-Aboriginal), the predicted Application Case ILCRs exceeded their respective target thresholds, resulting in a high magnitude of risk (ILCR $>1 \times 10^{-4}$). The impact related to the Project was considered minimal, with less than a 2% increase in exposure from Base Case to Application Case, and Project only ILCRs (Application Case minus Base Case) were below the acceptable threshold for all receptors assessed. The exposure to arsenic was primarily the result of background dietary intake, which contributed over 80% of total dose. Nonetheless, the estimated ILCRs for the seasonal receptors are at the low end of the range of background exposure for the general Canadian population, and are much lower than the background estimates for populations near point sources. • Therefore, although the resulting ILCRs are classified as a “high” magnitude of risk, the overall magnitude of risk from the Project is likely negligible for Aboriginal and non-Aboriginal seasonal users, based on the conservatism in the assessment, and comparison to average Canadian exposure to arsenic.

COPC = constituent of potential concern; ESA = effects study area; ILCR = incremental lifetime cancer risk; TRV = toxicity reference value; HHRA = human health risk assessment; TK = Traditional Knowledge; > = greater than; µg/kg/day = micrograms per kilogram per day; µg/L = micrograms per litre; mg/kg/day = milligrams per kilogram per day.

Table 5.2-5 Further Analysis of Inorganic Mercury and Determination of Magnitude of Potential Risk to Human Health

Analysis Criteria	Discussion
Magnitude of predicted risk estimate in the impact case	• Inorganic mercury exhibited HQs greater than 1.0 for the seasonal Aboriginal toddler (HQ = 1.3) and the Aboriginal child (HQ = 1.1) in the Application Case. The largest exposure to inorganic mercury was through the consumption of fish (Figure 5.2-1).
Comparison of Base Case to Application Case (change as a result of the Project)	• For the Project alone (i.e., the Application Case minus the Base Case), risks were below the target threshold with an HQ of 0.2 for both the toddler and child Aboriginal seasonal user.
Significant Exposure Pathways	• The most significant exposure pathway for inorganic mercury was the consumption of fish, which contributed to 94% of total exposure dose (Figure 5.2-1). • After the consumption of fish, the next most significant pathways were consumption of game meat (3% of total dose) and background dietary intake (2% of total dose).
Conservatism and uncertainty in predictions	• Country food predictions are based on soil quality and deposition rates for receptor locations in proximity to the mines and on water quality predictions at Lac de Gras and Lac du Sauvage (the most affected lakes in the ESA); therefore, applying these concentrations to the entire ESA is considered conservative. The water and fish predictions were based on conservative assumptions. For example, the maximum predicted mercury concentration across all stations at Lac de Gras and Lac du Sauvage, and across all operation phases was selected as the exposure concentration for surface water and as the starting point for predicting fish tissue concentrations. The bioaccumulation factor (BAF) for mercury was based on infrequently detected water concentrations, which introduces some uncertainty. However, the predicted Base Case concentration of total mercury in fish tissue (0.3 mg/kg) was at the high end (approximately 80th percentile) of the concentrations measured in baseline fish samples. Therefore, the predictions are considered realistic. Paired methyl mercury and total mercury analyses were conducted on several fish tissue samples; therefore, the fraction of inorganic and organic mercury assumed for fish tissue was considered representative of site-specific conditions. Several sources of uncertainty in the HHRA relate to the air quality predictions and deposition rates used to predict COPC concentrations in soil and country food (game meat, berries, and traditional plants). The air quality and deposition rate predictions use the maximum emission rates from the Project; however, this is a conservative assumption because most equipment does not operate at its maximum capacity on a continuous basis. This assumption can lead to overestimation of the potential Project impacts for the longer averaging periods (24-hour and annual). • Assumptions of organic versus inorganic mercury fractions in the various environmental media are also associated with uncertainty. It was assumed that mercury was 100% in the inorganic form in water, sediment, air, and vegetation, and 25% in the inorganic form in game meat and background food; however, because these pathways contributed little (less than 6%) to the overall exposure dose, results are not very sensitive to these assumptions.

Table 5.2-5 Further Analysis of Inorganic Mercury and Determination of Magnitude of Potential Risk to Human Health

Analysis Criteria	Discussion
Conservatism in the exposure assumptions	• The exposure assessment used site-specific chemistry data and exposure intake values for the Northern Aboriginal populations as available. Although receptors were only assumed to access the ESA seasonally (three months of the year), exposure doses were not amortized and a chronic toxicity reference value was used as per Health Canada guidance (Haber and Meek 2013). • The exposure assessment assumed that Aboriginals obtained 100% of their fish from the ESA; however, it is more likely that people fish in other areas outside of the ESA as well. In addition, only the toddler and child Aboriginal receptors exhibited a (marginally) unacceptable risk, and it is unlikely that very young people would be present on hunting and fishing trips of a long duration. It is possible that children of fishers could be exposed to fish that were preserved or frozen; however, it is unlikely that fish from the ESA would be consumed at as high a rate on a year-round basis. • Background dietary exposure was assumed to be equivalent to that of an urban Canadian population (Whitehorse data used), which is a conservative assumption given that the seasonal receptors were assumed to obtain a large portion of their daily calories from country foods.
Conservatism in the toxicity reference values used for mercury	• Given that the primary pathways driving risk were the ingestion food items, the discussion provided below is for TRVs for the oral pathway. • The oral reference dose (RfD) used in the risk assessment (0.0003 mg/kg/day was obtained from the US EPA IRIS (US EPA 1995). The RfD is based on the lowest observed effects levels (LOAELs) from three studies in which rats were exposed to mercuric chloride (inorganic form of mercury) for approximately 60 days. The most sensitive endpoint was the induction of kidney disease. An uncertainty factor of 1,000 was applied: a factor of 10 for use of a LOAEL, a factor of 10 for sub-chronic duration, and a factor of 10 for extrapolation from animals to humans and sensitive populations.
Potential health effects	• The major target organ of toxicity following oral exposure to inorganic mercury is the kidneys, whereas the organic form of mercury is associated with neurological effects. Chronic dermal exposure to inorganic mercury has also been associated with contact dermatitis in occupation exposure studies (ATSDR 1999).
Magnitude of risk	• For seasonal Aboriginal toddlers and children, the predicted Application Case HQs marginally exceeded the threshold, resulting in low magnitude of risk. However, there was minimal impact related to the Project, and Project only risk estimates (Application Case minus Base Case) are considered acceptable for all receptors. The exposure to inorganic mercury is primarily due to consumption of fish, which contributed 94% of total dose. The RfD for mercury is considered very conservative as it was derived using an uncertainly factor of 1,000, and is similar in magnitude to the RfD for methyl mercury (0.00023 mg/kg/day), which is considered the more toxic of the two forms of mercury. Risk estimates for methyl mercury were considered acceptable for all receptors. • Therefore, although the resulting risk estimate is classified as a low magnitude of risk, the overall risk from the Project is likely negligible for Aboriginal and non-Aboriginal Seasonal Users.

COPC = constituent of potential concern; ESA = effects study area; HHRA = human health risk assessment; HQ = hazard quotient; LOAEL = lowest observed adverse effects level; RfD = Reference Dose; TRV = toxicity reference value; US EPA = United States Environmental Protection Agency; IRIS = Integrated Risk Information System; µg/kg; mg/kg/day = milligrams per kilogram per day.

Table 5.2-6 Further Analysis of Selenium and Determination of Magnitude of Potential Risk to Human Health

Analysis Criteria	Discussion
Magnitude of predicted risk estimate in the impact case	**Non-cancer assessment:** • Selenium exhibited an HQ greater than 1.0 for the seasonal Aboriginal toddler (HQ = 1.2) in the Application Case. The largest contribution to exposure was through background dietary intake (Figure 5.2-1).
Comparison of Base Case to Application Case (change as a result of the project)	• ***Non-Cancer Assessment*** For the Project alone (i.e., the Application Case minus the Base Case), risks were below the target threshold with an HQ of 0.3 for the toddler Aboriginal seasonal user.
Significant Exposure Pathways	• Background dietary exposure accounted for 71% of total exposure for toddler Aboriginal seasonal users. Exclusion of background dietary intake resulted in an HQ of 0.3. Background dietary exposure information was obtained from a survey of average Canadian consumption patterns and selenium concentrations in market food items in Toronto (Health Canada 2011). These data are unlikely to reflect the actual background dietary exposure in communities near the ESA, given that there is a higher reliance on country foods in this area. The most significant background contribution of selenium came from milk, eggs, bread, and pasta (approximately 50% of total background dietary intake). • The next highest contribution to total exposure is the consumption of fish, which accounts for 27% of the total dose. The remaining pathways (ingestion of wild game, plants, berries, and exposure to water, air, and soil) accounted for only 2% of the total selenium dose.
Conservatism and uncertainty in predictions	• Country food predictions were based on soil quality and deposition rates for receptor locations in proximity to the mines and on water quality predictions at Lac de Gras and Lac du Sauvage (the most affected lakes in the ESA); therefore, applying these concentrations to the entire ESA is considered conservative. • The water and fish predictions were based on conservative assumptions. For example, the maximum predicted selenium concentration across all stations at Lac de Gras and Lac du Sauvage, and across all operation phases, was selected as the exposure concentration for surface water and as the starting point for predicting fish tissue concentrations. The BAFs for predicting fish tissue concentrations were based on measured data from the ESA (paired water and fish samples). Selenium was frequently undetected in water samples; therefore, there is some uncertainty in the BAF for selenium. However, because the maximum calculated BAF was selected to predict fish concentrations in the assessment, the resulting fish tissue concentrations are considered conservative. For example, the predicted Base Case selenium tissue concentration (0.55 mg/kg) corresponded to roughly the 95th percentile of measured baseline fish tissue concentrations, confirming the conservatism of the predictions.
Conservatism in the exposure assumptions	• The exposure assessment used site-specific chemistry data and exposure intake values for the Northern Aboriginal populations as available. • Although receptors were only assumed to access the ESA seasonally (three months of the year), exposure doses were not amortized and a chronic toxicity reference value was used as per Health Canada guidance (Haber and Meek 2013). The exposure assessment assumed that Aboriginals obtained 100% of their fish from the ESA; however, it is more likely that people fish in other areas outside of the ESA as well. In addition, only the toddler Aboriginal receptors exhibited a (marginally) unacceptable risk, and it is unlikely that very young people would be present on hunting and fishing trips of a long duration. It is possible that the children of fishers could be exposed to fish that were preserved or frozen; however, it is unlikely that fish from the ESA would be consumed at as high a rate on a year-round basis. • Background dietary exposure was assumed to be equivalent to that of an urban Canadian population (Toronto data used), which is a conservative assumption given that the seasonal receptors were assumed to obtain a large portion of their daily calories from country foods.

Table 5.2-6 Further Analysis of Selenium and Determination of Magnitude of Potential Risk to Human Health

Analysis Criteria	Discussion
Conservatism in the toxicity reference values used for selenium	• Given that the primary pathways driving risk were the ingestion food items, the discussion provided below is for TRVs for the oral pathway. • Health Canada (2010b) has derived age-specific oral RfDs for selenium. The adult RfD is based on a no–observed-adverse-effect level (NOAEL) of 800 µg/day for the critical effect of selenosis (Yang and Zhou 1994; as cited in Health Canada 2010b). An uncertainty factor of 2 was applied to protect sensitive individuals resulting in an RfD of 0.0057 mg/kg/day. The infant RfD is based on a NOAEL of 60 µg/L from a study by Shearer and Hadjimarkos (1975; as cited in Health Canada 2010b). The NOAEL was adjusted for milk intake rate (0.78 L/day), and upper limit intake levels were derived for toddler, children, and adolescent age groups from the infant value using relative body weights. The resulting RfD for toddlers is 0.0062 mg/kg/day.
Potential health effects	• Health Canada (2010b) and the Institute of Medicine (IOM 2000) consider selenium to be a required nutrient. Most toxicity information for oral exposure to selenium is from animal studies using selenite, selenate, selenium sulphides, and organic selenium compounds. There have been accidental poisoning cases in humans, but few fatalities have been reported. In animals, the most acutely orally toxic compounds of selenium are sodium selenite and sodium selenate (ATSDR 2003). Respiratory effects (including pulmonary edema and lesions) in humans and animals have been reported, as well as tachycardia, gastrointestinal distress (including nausea, vomiting, diarrhea, and abdominal pain), hematological changes (in men), immunological and lymphoreticular enhancement, and neurological effects (including aches pains and irritability) in humans following ingestion of very high concentrations of selenium (ATSDR 2003).
Magnitude of risk	• For seasonal Aboriginal toddlers, the predicted Application Case HQs marginally exceeded the threshold, resulting in a low magnitude of risk. However, there was minimal impact related to the Project, and Project only risk estimates (Application Case minus Base Case) are considered acceptable for all receptors. The primary contribution to selenium exposure to was the background dietary intake, which contributed nearly three quarters of total dose. Exclusion of background dietary intake results in an acceptable risk (HQ of 0.3). • Therefore, although the resulting risk estimate is classified as a low magnitude of risk, the overall risk from the Project is likely negligible for Aboriginal and non-Aboriginal Seasonal Users.

BAF = bioaccumulation factor; ESA = effects study area; HQ = hazard quotient; RfD = Reference Dose; TRV = toxicity reference value; US EPA = United States Environmental Protection Agency; mg/kg/day = milligrams per kilogram per day; µg/L = micrograms per litre; L/day = litres per day.

5.3 Wildlife Health Effects - Multimedia Assessment

The wildlife health assessment considered the Base Case (i.e., anticipated conditions in the absence of the Project) and the Application Case (i.e., anticipated conditions if the Project is approved, which includes the cumulative effects of the Base Case and Project effects) as described in Section 1.6. The potential wildlife health risks, as indicated by HQs associated with each Case were evaluated, and the results were compared to estimate the incremental effects of the Project.

As described in Section 4.3.1.3, COPCs were only identified for the aquatic environment (i.e., there were no COPCs for pathways relevant to terrestrial feeding wildlife), and therefore, the wildlife health assessment focusses primarily on receptors feeding at least in part in aquatic habitats. However, given the importance of barren-ground caribou as an important food and economic source to humans and to the tundra ecosystem, and given the existing presence of diamond mines that may affect barren-ground caribou, this terrestrial-feeding receptor was also retained in the wildlife health assessment. The multimedia assessment sums the exposures due to ingestion of several dietary items, water, and incidentally consumed media (e.g., soil and sediment) that are predicted to be affected by the Project.

As per the approach outlined in Section 4.5.3, the wildlife health risk characterization was conducted using two sets of TRVs, reflecting very high levels of conservatism (i.e., lower-TRVs) for listed receptors (grizzly bear and rusty blackbird) and moderately high levels of conservatism (i.e., upper-TRVs) for all other receptors in the effects assessment. Exceedances of lower-TRVs may or may not actually result in adverse effects, although COPC exposures below the lower-TRVs indicate a lack of potential risks with high confidence. Upper-TRVs provide a more realistic assessment of the potential for adverse effects on wildlife receptors, as these TRVs are associated with dietary intakes that have been observed to result in adverse effects in sensitive test organisms. However, as the upper-TRVs represent the most sensitive documented relevant endpoints, they still provide a level of protection to wildlife receptors and should not be interpreted as thresholds for the actual study populations or receptors, particularly where the surrogate species is dissimilar to the site-specific receptor of concern. The risk characterisation involved comparing the predicted estimated daily intake (EDI) to the TRVs to determine hazard quotients (HQs).

Mercury can occur as inorganic mercury or methyl mercury in food items for wildlife. As described in Appendix D, mercury in terrestrial food items, aquatic plants, aquatic invertebrates, and fish are assumed to be primarily in methylated form. Thus, TRVs for the wildlife receptors are based on methyl mercury.

The HQ results and estimated magnitude of risk are first discussed for barren-ground caribou (Section 5.3.1), and then for the aquatic feeding wildlife receptors.

5.3.1 Barren-Ground Caribou

Table 5.3-1 present the risk characterization results for the Base and Application Case for barren-ground caribou.

The risk characterization results for multimedia exposure to arsenic, chromium, methyl mercury, and selenium indicated that HQs were all less than one (1.0) for caribou in both the Base Case and the Application Case, indicating that health risks due to exposure to the above COPCs are negligible.

Therefore, the impact on barren-ground caribou under the Application Case (considering cumulative effects of the Project plus existing Ekati and Diavik mines) is anticipated to be negligible. The multimedia risk assessment evaluated constituents emitted from the Project that may be present in soil, food, and water, as well as the potential for bioaccumulation of these constituents within the food chain.

Table 5.3-1 Hazard Quotients Results for Barren-Ground Caribou

Receptor	Arsenic	Chromium	Mercury	Selenium
Base Case				
Caribou	<0.1	<0.1	<0.1	<0.1
Application Case				
Caribou	<0.1	0.1	0.1	<0.1

< = less than.

5.3.2 Aquatic-Feeding Wildlife

Table 5.3-2 present the risk characterization results for the Base and Application Cases for the aquatic-feeding mammals and birds.

The risk characterization results for arsenic, methyl mercury, and selenium indicated that HQs were less than one (1.0) for all receptors assessed in both the Base Case and the Application Case. For chromium, the HQs were less than one (1.0) under both the Base Case and the Application Case for all receptors assessed, except semi-palmated sandpiper. This finding indicates that, with the exception of chromium for semi-palmated sandpiper, health risks to aquatic-feeding wildlife receptors from COPCs are negligible and the incremental impact on wildlife as a result of emissions of these COPCs under the Application Case (considering cumulative effects of the Project plus existing Ekati and Diavik mines) is anticipated to be negligible.

Table 5.3-2 Hazard Quotients for Aquatic-feeding Wildlife Receptors

Receptor	Arsenic	Chromium	Methyl Mercury	Selenium
Base Case				
Grizzly bear	<0.1	<0.1	0.1	<0.1
Muskrat	0.1	0.1	0.1	<0.1
Rusty blackbird	0.3	0.5	0.6	0.2
Common merganser	<0.1	<0.1	0.1	0.1
Green-winged teal	<0.1	<0.1	0.2	<0.1
Semi-palmated sandpiper	0.8	**1.4**	0.5	0.3
Bald eagle	<0.1	<0.1	0.1	<0.1

Table 5.3-2 Hazard Quotients for Aquatic-feeding Wildlife Receptors

Receptor	Arsenic	Chromium	Methyl Mercury	Selenium
Application Case				
Grizzly bear	<0.1	<0.1	0.1	<0.1
Muskrat	0.1	0.1	0.1	0.2
Rusty blackbird	0.4	0.7	0.9	0.5
Common merganser	<0.1	<0.1	0.1	0.2
Green-winged teal	<0.1	0.1	0.2	0.1
Semi-palmated sandpiper	0.8	**1.5**	0.5	0.6
Bald eagle	<0.1	<0.1	0.1	0.2

Note: Underlined = Species of Special Concern.
Bold and shaded values exceed a hazard quotient of 1.0; < = less than.

The hazard quotients for chromium for the semi-palmated sandpiper exceeded one (1.0) for the Base Case (HQ = 1.4) and for the Application Case (HQ = 1.5). For both Cases, exposure to chromium by the semi-palmated sandpiper is predominantly due to sediment (responsible for 92 to 94% of the EDI) with the remaining EDI contribution being from aquatic insects (6 to 8%) and water (less than 1%).

The magnitude of risks resulting from chromium exposure by the semi-palmated sandpiper is discussed in Table 5.3-3.

Table 5.3-3 Further Analysis of Chromium and Determination of Magnitude of Risk for Aquatic-Feeding Wildlife

Analysis Criteria	Discussion
Magnitude of hazard quotients (HQs)	• HQs for the caribou, grizzly bear, muskrat, rusty blackbird, common merganser, green-winged teal, and the bald eagle are all less than one (1.0) for both scenarios indicating negligible risk to these receptors. • HQs for the semi-palmated sandpiper were of low magnitude, ranging from 1.4 to 1.5 for both the Base and Application Case.
Comparison of Base and Application Cases	• HQs for the semi-palmated sandpiper showed a 7% increase from Base to Application Case entirely due to an increase in exposure to aquatic insects (relative contribution to HQ increased from 5.8 to 7.5% from the Base to Application Case) even though exposure to chromium was mainly through incidental sediment ingestion because there was no project impact on sediment chromium concentrations.
Uncertainty and conservatism in exposure estimates	• The assumption of 100% bioavailability of chromium in birds is likely to result in an overestimate of the dose of chromium from consumed sediment because most of the chromium in sediment would have low bioavailability (CCME 1999). • Literature-based BAFs (Appendix D) were used to approximate the transfer of metals to aquatic invertebrate tissues. The water to aquatic invertebrate BAF applied in the food chain model was 955 - 1,128 L/kg wwt (based on an equation from DeForest et al. [2007] that varies with water concentration). The aquatic invertebrate BAF is considered appropriate (i.e., neither over- nor under-protective) because it is close to the site-specific fish BAF value of 1,429 L/kg wwt.

Table 5.3-3 Further Analysis of Chromium and Determination of Magnitude of Risk for Aquatic-Feeding Wildlife

Analysis Criteria	Discussion
Uncertainty and conservatism in the toxicity reference value	• The avian TRVs based on data compiled and reviewed by the US EPA (2008). Both the lower- and upper-TRVs are based on the lower range of the data sets and provide protective benchmarks for evaluating ecological effects. • These TRVs are based on feeding studies with soluble (and therefore highly bioavailable) chromium, and therefore, are likely to result in far greater absorption of chromium from food and incidental sediment ingestion than would be experienced by wildlife. • The upper-TRV for birds was a LOAEL based on reproduction and survival effects in black ducks exposed to chromium alum dodecahydrate [$KCr(SO_4)_2.12(H_2O)$] in food. This LOAEL was well below (at least 4-fold lower), than the other LOAELs compiled by US EPA (2008) suggesting that the upper-TRV for birds is protective. • The semi-palmated sandpiper is not considered vulnerable, threatened, or of special concern (refer to Section 4.3.1), and therefore, the upper-TRV is considered to offer an appropriate level of protection.
Magnitude of risk	• The absolute magnitude of the estimated HQs for chromium in the semi-palmated sandpiper is considered low (HQ 1.4 to 1.5) resulting in an approximate 7% increase due to project impacts. • The chromium TRVs are based on a more bioavailable form (i.e., in laboratory toxicity studies) of the metal than would be present in sediments; therefore, the TRV is considered to be protective of birds such as sandpipers that incidentally consume large amounts of sediment. • Considering the levels of protection offered by the TRV, the expected low bioavailability of chromium in sediment, the overall magnitude of risk to wildlife from the project is likely to be negligible.

BAF = bioaccumulation factor; HQ = hazard quotient; L/kg wwt = litres per kilograms in wet weight; LOAEL = lowest observable adverse effect level; TRV = toxicity reference value; US EPA = United States Environmental Protection Agency.

The magnitude of chronic risks to aquatic-feeding wildlife from exposure to chromium is expected to be negligible for the grizzly bear, muskrat, rusty blackbird, common merganser, green-winged teal, and bald eagle.

Hazard quotients for the semi-palmated sandpiper exceeded one (1.0) but were within the low range (less than five [5]). For the semi-palmated sandpiper, the magnitude of chronic risks under the Application Case (considering cumulative effects of the Project plus existing Ekati and Diavik mines) is low and expected to be negligible because there was minimal change in HQs (increase of 7% from Base to Application Case) as a result of the Project, and because risks are likely to have been overestimated considering:

- the assumption of 100% chromium bioavailability in aquatic invertebrates and sediment, and
- application of protective TRVs based on a more bioavailable form of chromium.

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6 PREDICTION CONFIDENCE AND UNCERTAINTY

Sources of uncertainty in the assessment were addressed by using conservative assumptions where possible. These sources of uncertainty and the predicted effect on the results of the risk assessment are described below. After identifying the major sources of uncertainty, a level of confidence was assigned to each residual effect. Important considerations with respect to prediction confidence included:

- The number of samples and quality of the baseline data were considered to be adequate for characterizing Base Case metal, PAH, and dioxin/furan concentrations in environmental media (soil, sediment, and surface water), terrestrial vegetation, and fish tissue within the ESA.
- The air quality and deposition rate predictions use the maximum emission rates from the Project; however, this assumption is conservative because most equipment does not operate at its maximum capacity on a continuous basis. This assumption can lead to overestimation of the potential Project effects for the longer averaging periods (i.e., 24-hour and annual averages).
- The soil concentrations used as inputs for the estimation of vegetation, small mammal, and by extension (via vegetation), caribou tissue concentrations were the 95% upper confidence limit on the mean (95% UCLM) from the soil samples collected within the ESA. Given that wild game and vegetation may be present throughout the ESA, it was considered reasonable to use a conservative central tendency estimate such as a 95% UCLM for this predictive modelling.
- The deposition modelling approach for predicting soil concentrations was based on established US EPA procedures; it was applied in a way considered to overpredict soil concentrations because no loss processes from soils due to weathering, leaching, or burial were included. Wet and dry particulate deposition rates were used to estimate soil concentrations and vegetation concentrations for each assessment case (i.e., Base and Application Cases). These soil and vegetation concentrations were then used to predict concentrations in small mammals and caribou. Therefore, conservatism built into the deposition modelling is propagated in the estimation of soil, vegetation, and wild game concentrations. A conservative approach to applying the deposition rates was taken wherein deposition was considered to be occurring for 3 years of construction and 10 years of operations for the Application Case. Additionally, the deposition rates that were used were the maximum predicted deposition rates for each phase. This makes it likely that the soil concentrations used in COPC screening and the vegetation and wild game concentrations applied in the food chain model have been over-predicted by utilizing these maximum deposition rates.
- Fish tissue residues were predicted for Aboriginals and for wildlife considering their potential exposure to fish muscle. Sufficient baseline data were available (i.e., fish muscle data and water data) to calculate site-specific BAFs (year and lake) for fish muscle. The BAF derivation method is provided in Section 8.5.5 of the DAR. All non-detected water and tissue concentrations were set to the corresponding detection limit, which resulted in conservative BAFs. Only muscle tissue concentrations of Lake Trout and Round Whitefish were used in the BAF calculations because they are abundant in Lac du Sauvage and Lac de Gras, form a key component of the lake ecosystem, and are consumed by Aboriginals (Section 8.5.5 of the DAR). Each lake-, species-, and year-specific median BAF was categorized according to its reliability based on its frequency of detection in water and tissue data (i.e., a higher number of detected values in water and fish tissue corresponds to higher reliability). The maximum reliable BAF was selected to predict Base and Application Case fish

tissue concentrations. The use of maximum (as opposed to average or median BAFs) is protective because it results in fish tissue predictions representative of the upper range of observed accumulation in ESA.

- The maximum depth-averaged surface water concentrations (under ice and open water) were applied in the multi-media exposure assessments for human and wildlife health that were based on reasonable “worst-case” loading rates for each COPC rather than average loading rates. Thus, the resulting COPC exposure estimates represent the upper range of predicted conditions in the ESA as a result of the Project.
- Exposure parameters for the human health assessment were based on Canadian data, with an emphasis on northern Aboriginal populations for consumption of country foods. Seasonal Aboriginal receptors were assumed to obtain 100% of their country foods from within the ESA, and non-Aboriginal receptors were assumed to obtain 50% of their game and fish from the ESA, which is considered to be conservative. Aboriginal receptors of all ages were assumed to access the ESA on a seasonal basis, which is also conservative, given that young children are unlikely to accompany adults on hunting and fishing trips of long duration.
- For both human health and wildlife health, there are significant sources of uncertainty when using animal studies for extrapolation to people or other animals, including the bioavailability of the substance (in laboratory studies, metals are often administered as bioavailable salts, whereas environmental exposures are likely to be in much less bioavailable forms associated with sulphides or oxides) and the exposure method used (administration may be via drinking water, food, gavage, or injection). Thus, the selected TRVs may be over-conservative because they assume high bioavailability of COPCs, which is often not the case in environmental exposures.

Overall, there were several model inputs and assumptions that were considered to result in over-prediction of exposure and risks for both human and wildlife health.

The confidence in the predicted residual effect conclusions is presented in Table 6-1 (human health – air quality assessment), Table 6-2 (human health – multimedia assessment), and Table 6-3 (wildlife health) below.

Table 6-1 Prediction Confidence for Each Residual Effect in the Human Health Air Quality Assessment

Constituent of Potential Concern (COPC)	Receptor	Confidence for each Residual Effect Conclusion
Acute Inhalation Assessment (1-Hour)		
Aluminum	Misery Camp	High
	Maximum off-site location (MPOI)	High
Barium	Maximum off-site location (MPOI)	High
Beryllium	Maximum off-site location (MPOI)	High
Cadmium	Maximum off-site location (MPOI)	High
Chromium	Maximum off-site location (MPOI)	High
Iron	Maximum off-site location (MPOI)	High

Table 6-1 Prediction Confidence for Each Residual Effect in the Human Health Air Quality Assessment

Constituent of Potential Concern (COPC)	Receptor	Confidence for each Residual Effect Conclusion
Manganese	Maximum off-site location (MPOI)	High
Nickel	Maximum off-site location (MPOI)	High
All COPCs	All other locations assessed	High
Acute Inhalation Assessment (24-Hour)		
Nitrogen Dioxide	Maximum off-site location (MPOI)	High
Aluminum	Maximum off-site location (MPOI)	High
Cadmium	Maximum off-site location (MPOI)	High
Chromium	Maximum off-site location (MPOI)	High
Iron	Maximum off-site location (MPOI)	High
Manganese	Maximum off-site location (MPOI)	High
Nickel	Maximum off-site location (MPOI)	High
All COPCs	All other locations assessed	High
Chronic Inhalation Assessment (Annual)		
Chromium	Worker Camps (Diavik Camp, Ekati Camp/Admin and Misery Camp)	High
	All other locations assessed	High
All COPCs	All other locations assessed	High
Particulate Matter Assessment		
PM_{10} (24-hour)	Worker Camps (Diavik Camp and Misery Camp)	Moderate
PM_{10} (24-hour)	Maximum off-site location (MPOI)	Moderate
$PM_{2.5}$ (24-hour)	Worker Camps (Diavik Camp and Misery Camp)	Moderate
$PM_{2.5}$ (24-hour)	Maximum off-site location (MPOI)	Moderate
PM_{10}/$PM_{2.5}$ (24 hour)	All other locations evaluated	Moderate
PM_{10}/$PM_{2.5}$ (chronic/annual)	All locations evaluated	Moderate

COPC = constituent of potential concern; MPOI = maximum point of impingement; $PM_{2.5}$ = particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller; PM_{10} = particulate matter with a mean aerodynamic diameter of 10 microns or smaller.

The confidence in the residual effects predicted for aluminum, barium, beryllium, cadmium, chromium, iron, manganese, and nickel (for the 1-hour inhalation assessment) is high. Similarly, confidence in the residual effects predicted for nitrogen dioxide, aluminum, cadmium, chromium, iron, manganese and nickel (in the 24-hour inhalation assessment) is high. Prediction confidence for both the 1-hour and 24-hour inhalation assessments is high based on the conservatism in the air modelling predictions (equipment and operations running continuously under maximum capacity) and the assessment of the maximum exceedance within the ESA (maximum off-site receptor location outside the mine site area [MPOI]).

The confidence in the residual effects predicted for chromium in the chronic air quality assessment is high based on the conservatism in the air modelling predictions, and the low magnitude of risk even when based on a conservative TRV (e.g., use of a TRV for chromium (VI)).

The confidence in the residual effects conclusions for remaining COPCs in the air quality assessment is high based on the conservatism in the air modelling predictions (equipment and operations running continuously under maximum capacity).

The confidence in the residual effects predicted for short-term (24-hour) exposure to particulate matter is moderate, given that there is uncertainty in the health effects of particulate matter based on the literature review and whether the highly conservative particulate matter predictions will be realized at locations where workers are present.

Table 6-2 Prediction Confidence for Residual Effects Conclusions in the Human Health Risk Assessment

Constituent of Potential Concern	Receptor	Confidence for each Residual Effect Conclusion
Arsenic	Seasonal Users (Aboriginal and non-Aboriginal)	High
Chromium		High
Methyl Mercury		High
Selenium		High

Table 6-3 Prediction Confidence for Residual Effects Conclusions in the Wildlife Health Risk Assessment

Constituent of Potential Concern	Receptor	Confidence for each Residual Effect Conclusion
Arsenic	Caribou	High
Chromium		High
Methyl Mercury		High
Selenium		High
Arsenic	Aquatic-feeding mammals and aquatic feeding birds	High
Chromium		High
Methyl Mercury		High
Selenium		High
All Constituents	Terrestrial-feeding wildlife	High

The confidence in the residual effects predicted for arsenic, chromium, methyl mercury, and selenium in the human and wildlife health risk multimedia assessment is considered to be high. The risk estimates for the Application Case for these COPCs are similar to those for the Base Case, or are unchanged from Base Case and the absolute magnitudes of HQs are low, even when based on conservative effects thresholds.

7 RESIDUAL IMPACT CLASSIFICATION AND SIGNIFICANCE

This section presents the classification and evaluation of significance of the predicted potential residual effects identified in Section 5.

7.1 Methods

The effects analysis methods for the human and wildlife health risk assessments are different in some notable ways from those used by other components. Specifically, the assessment of potential effects on human and wildlife health results in the generation of risk factors that inherently consider the geographic extent, duration, frequency, and other characteristics of the predicted changes to the environment that may result from Project activities. As such, these attributes cannot be used to determine environmental significance, as they can with other components.

Instead, environmental significance for human and wildlife health is evaluated based on:

1) the potential magnitude of risk, as indicated by the HQ and ILCR results, considering the classification criteria in Table 1.7-1, as well as the considerations and discussions applied to assessing magnitude of risks in Sections 5.1, 5.2 and 5.3; and,

2) the degree of conservatism and uncertainty in the analysis.

Note that hazard quotients or ILCRs, by themselves, do not fully reflect the potential for harm, because the magnitude of any HQ or ILCR calculation is a function of the exposure and effects assessments, each of which depends on the realism or conservatism applied during the modelling procedure. Together, potential magnitude and conservatism (i.e., includes qualitative assessment of likelihood of risk) are used to determine overall risk which, in turn, is used to evaluate environmental significance. The second (conservatism and uncertainty) component of the above assessment of environmental significance is defined based on a review of the assumptions used to generate the risk predictions and the conservatism incorporated therein, as outlined in the magnitude of risk tables included in Section 5 and the prediction confidence and uncertainty discussed in Section 6. The risk predictions (i.e., magnitude of risk) are reviewed on a chemical-specific basis for both the human and terrestrial wildlife risk assessments.

Several areas of uncertainty and conservatism influenced the residual effects conclusions in Section 7.2, including:

- Multiple conservative exposure assumptions (such as Aboriginal receptors obtaining 100% of their country foods within the ESA).
- The uncertainty with the predictions in chemical media concentrations (deposition rates affecting predicted soil and vegetation quality, water quality concentrations affecting the prediction of COPCs in fish tissue). Multiple conservative assumptions have been utilized throughout the risk assessment so that confidence is high that risks have not been underestimated.

- The uncertainty associated with the bioavailability of the COPCs in soil or other media compared to the soluble forms of these materials used to dose test animals to derive wildlife TRVs. The bioavailability of the materials used to dose test animals is usually quite a bit higher than that found in site media, and as a result, confidence is high that risks have not been underestimated.
- The uncertainty factors included in the derivation of human health TRVs to account for effects on sensitive subpopulations and data gaps.
- A comparison of the risks predicted in the Base Case to those for the Application Case to understand how the Project contributes to the risk estimates.

A more detailed discussion about prediction confidence and uncertainty in the risk assessment is provided in Section 6.

As noted above, the criteria used to determine significance in the DAR are considered in the human and wildlife health risk assessment but are inherent in the risk estimation approach and results and are therefore not considered separate from the risk estimates. These include the following:

- **Direction** indicates whether an effect is considered negative (i.e., less favourable) or positive (i.e., beneficial). Potential adverse health effects as the result of exposure to COPCs are considered to be negative effects.
- **Geographic extent** refers to the area affected and is referred to as the ESA. Receptor locations are identified within the ESA and are assessed in the human health risk assessment. As a result, the geographic locations are set and risk estimates are calculated for each of these locations. The wildlife health risk estimates are based on “worst case” exposure within the ESA and are not scaled to the receptor’s home range size relative to the ESA (i.e., a receptor is assumed to spend its entire life within the ESA even though they only spend a part of the year in the area). As a result, geographic extent is fixed in the risk assessment and cannot be used to determine significance of a residual effect.
- **Duration** is defined as the amount of time from the beginning of an effect to when the effect on a VC has ended or dissipated to the point of not being detectable and is expressed relative to Project phases. Exposure duration is not an independent variable in the human health risk assessment, as it is necessary to assume an exposure duration in order to calculate an estimate of a daily exposure dose resulting from chronic exposure to the COPCs. For the wildlife health risk assessment, it is assumed that wildlife are continuously exposed to the maximum exposure concentrations achieved during the duration of the project (i.e., exposure and estimated risks are “worst case” and do not vary over the duration of the Project). As a result, duration cannot be used to determine significance of a residual effect.
- **Frequency** refers to number of times an effect is expected to occur over a given period. For the human health risk assessment, the frequency of exposure is not an independent variable as it is necessary to assume a particular exposure frequency to calculate an estimate of a daily exposure dose in accordance with risk assessment guidance, resulting from chronic exposure to the COPCs. For the wildlife health risk assessment, the frequency is assumed to be continuous for the duration of the Project. As a result, frequency cannot be used to determine significance of residual effect.

- **Reversibility** is defined as the probability and time required to return to a state that is similar to baseline or comparable to similar environments not affected by the Project. The human health risk assessment does not include an assessment of reversibility of potential health effects and this not something that can be determined for people. For the wildlife health risk assessment, reversibility is considered qualitatively to provide context only when risks are expected to be unacceptable (i.e., based on the magnitude of risk and conservatism considerations outlined above) for the duration of the Project.
- **Likelihood** of the predicted Project effects occurring is high if the Project proceeds. A qualitative evaluation of likelihood is incorporated into the conservatism assessment described above.

7.2 Results

7.2.1 Air Quality Assessment

Residual effects on human health for exposure to COPCs in air (based on the short- and long-term inhalation and particulate matter assessments) resulting from emissions from the Project are classified in Table 7.2-1.

Table 7.2-1 Significance of Predicted Risks to Human Health from Inhalation Exposure for the Construction Case and Application Case

Constituent of Potential Concern (COPC)	Receptors	Magnitude of Risk	Conservatism and Rationale	Residual Effects Conclusion	Mitigation Needed?
Acute Inhalation Assessment (1 Hour)					
Aluminum	Misery Camp	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentration exceeded the acute exposure limit at Misery Camp under the Construction Scenario, with a prediction of 38 hourly exceedances in a year. However, the predicted concentrations are below those reported in the literature to result in health effects, even for longer exposures.	Not significant	The mitigation recommended for particulate matter will address short-term exposure to aluminum [(a)]
	Maximum off-site location (MPOI)	Low	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentration at the MPOI exceeded the acute exposure limit in the Construction Case and Application Case, at a frequency of 3,346 and 3,436 hours in a year, respectively. However, the predicted concentrations are below those reported in the literature to result in health effects, even for longer exposures. In addition, the maximum off-site location in the Construction Case and Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present during the hours in a year when concentrations are predicted to be elevated.	Not significant [(b)]	No
Barium	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentrations exceeded the acute exposure limit at the MPOI under the Application Case, but the predicted concentrations are below those reported in the literature to result in health effects, even for longer exposures. Two hourly exceedances in a year were predicted for barium at the maximum off-site location, which in the Application Case is along the perimeter of the Project fenceline and does not overlap with any of the other receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present during the hours in a year when concentrations are predicted to be elevated.	Not significant [(b)]	No
Beryllium	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentrations exceeded the acute exposure limit at the MPOI under the Application Case, but the predicted concentrations are below those reported in the literature to result in health effects. A single hourly exceedance in a year was predicted for beryllium at the maximum off-site location, which in the Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present during the hours in a year when concentrations are predicted to be elevated.	Not significant [(b)]	No
Cadmium	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentrations exceeded the acute exposure limit at the MPOI under the Application Case, but the predicted concentrations are below those reported in the literature to result in health effects. Three hourly exceedances in a year were predicted for cadmium at the maximum off-site location, which in the Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present during the hours in a year when concentrations are predicted to be elevated.	Not significant [(b)]	No
Chromium	Maximum off-site location (MPOI)	Low	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentration at the MPOI exceeded the acute exposure limit in the Construction Case and Application Case, at a frequency of 2,010 and 1,892 hours in a year, respectively. However, the predicted concentrations are below those reported in the literature to result in health effects, even for longer exposures (i.e., subchronic toxicological studies). In addition, due to a lack of speciation data, chromium was assumed to be present as hexavalent chromium, and therefore, the air predictions are likely an overestimate of hexavalent chromium concentrations. The maximum off-site location in the Construction Case and Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present during the hours in a year when concentrations are predicted to be elevated.	Not significant [(b)]	No

Table 7.2-1 Significance of Predicted Risks to Human Health from Inhalation Exposure for the Construction Case and Application Case

Constituent of Potential Concern (COPC)	Receptors	Magnitude of Risk	Conservatism and Rationale	Residual Effects Conclusion	Mitigation Needed?
Iron	Maximum off-site location (MPOI)	Low	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentration at the MPOI exceeded the acute exposure limit in the Construction Case and Application Case, at a frequency of 1,879 and 1,721 hours in a year, respectively. However, the predicted concentrations are below those reported in the literature to result in health effects, even for longer exposures, and below occupational thresholds set by the American Conference of Governmental Industrial Hygienists (ACGIH). In addition, the maximum off-site location in the Construction Case and Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present during the hours in a year when concentrations are predicted to be elevated.	Not significant [b]	No
Manganese	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentrations exceeded the acute exposure limit at the MPOI under the Application Case. Nine hourly exceedances in a year were predicted for manganese at the maximum off-site location. However, the predicted concentrations are below those reported in the literature to result in health effects, even for longer exposures. In addition, the maximum off-site location in the Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present during the hours in a year when concentrations are predicted to be elevated.	Not significant [b]	No
Nickel	Maximum off-site location (MPOI)	Low and Likely Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentrations exceeded the acute exposure limit at the MPOI under the Application Case. The predicted peak concentration at the MPOI is predicted to exceed the acute exposure limit in the Application Case, at a frequency of 24 hours in a year. However, the predicted concentrations are below those reported in the literature to result in health effects, even for longer exposures. The maximum off-site location in the Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas).The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present during the hours in a year when concentrations are predicted to be elevated.	Not significant [b]	No
All COPCs	All Other Receptor Locations	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The predicted peak concentrations at the remaining receptor locations were below acute thresholds, and therefore health effects as a result of short-term (1 hour) exposure during construction and operations are not anticipated.	Not significant	No

Table 7.2-1 Significance of Predicted Risks to Human Health from Inhalation Exposure for the Construction Case and Application Case

Constituent of Potential Concern (COPC)	Receptors	Magnitude of Risk	Conservatism and Rationale	Residual Effects Conclusion	Mitigation Needed?
Acute Inhalation Assessment (24 Hours)					
Nitrogen Dioxide	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts. The predicted peak concentrations exceeded the acute exposure limit at the MPOI under the Application Case. However, the predicted concentrations are below those at which health effects are reported in the literature. One daily exceedance in a year was predicted for nitrogen dioxide at the maximum off-site location, which in the Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present for 24 hours on the single day in a year when concentrations are predicted to be elevated.	Not significant [b]	No
Aluminum	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts. The predicted peak concentrations at the MPOI are predicted to exceed the acute exposure limit in the Construction Case and Application Case, at a frequency of 23 and 17 days in a year, respectively. However, the predicted concentrations are below those at which health effects are reported in the literature. The maximum off-site location in the Construction Case and Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present for 24 hours on the days in a year when concentrations are predicted to be elevated.	Not significant [b]	No
Cadmium	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts. The predicted peak concentrations exceeded the acute exposure limit at the MPOI under the Application Case. However, the predicted concentrations are below those at which health effects are reported in the literature. Ten daily exceedances in a year were predicted for cadmium at the maximum off-site location, which in the Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present for 24 hours on the days in a year when concentrations are predicted to be elevated.	Not significant [b]	No
Chromium	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts. In addition, due to a lack of speciation data, chromium was assumed to be present as hexavalent chromium, and therefore, the air predictions are likely an overestimate of hexavalent chromium concentrations. The predicted peak concentrations at the MPOI exceeded the acute exposure limit in the Construction Case and Application Case, at a frequency of nine and eight days in a year, respectively. The maximum off-site location in the Construction Case and Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present for 24 hours on the days in a year when concentrations are predicted to be elevated.	Not significant [b]	No
Iron	Maximum off-site location (MPOI)	Low	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts. The predicted peak concentrations at the MPOI exceeded the acute exposure limit in the Construction Case and Application Case, at a frequency of 194 and 197 days in a year, respectively. However, the predicted concentrations are below those at which health effects are reported in the literature, and below occupational thresholds set by the American Conference of Governmental Industrial Hygienists (ACGIH). The maximum off-site location in the Construction Case and Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present for 24 hours on the days in a year when concentrations are predicted to be elevated.	Not significant [b]	No

Table 7.2-1 Significance of Predicted Risks to Human Health from Inhalation Exposure for the Construction Case and Application Case

Constituent of Potential Concern (COPC)	Receptors	Magnitude of Risk	Conservatism and Rationale	Residual Effects Conclusion	Mitigation Needed?
Manganese	Maximum off-site location (MPOI)	Low	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts. The predicted peak concentrations at the MPOI are predicted to exceed the acute exposure limit in the Construction Case and Application Case, at a frequency of 135 and 139 days in a year, respectively. However, the predicted concentrations are below those at which health effects are reported in the literature, and below occupational thresholds set by the American Conference of Governmental Industrial Hygienists (ACGIH). The maximum off-site location in the Construction Case and Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present for 24 hours on the days in a year when concentrations are predicted to be elevated.	Not significant [b]	No
Nickel	Maximum off-site location (MPOI)	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts. The predicted peak concentrations exceeded the acute exposure limit at the MPOI under the Application Case. However, the predicted concentrations are below those at which health effects are reported in the literature. Five daily exceedances in a year were predicted for cadmium at the maximum off-site location, which in the Application Case is along the perimeter of the Project fenceline and does not overlap with any of the receptor locations in the ESA (i.e., worker camps and recreational areas). The MPOI is not anticipated to have frequent, if any, use by humans; therefore, it is unlikely that there would be people present for 24 hours on the days in a year when concentrations are predicted to be elevated.	Not significant [b]	No
All COPCs	All Other Receptor Locations Evaluated	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts. The predicted peak concentrations at the remaining receptor locations were below acute thresholds, and therefore health effects as a result of short-term (24-hour) exposure during construction and operations are not anticipated.	Not significant	No
Chronic Inhalation Assessment (Annual)					
Chromium	Worker Camps (Diavik Camp, Ekati Camp/Admin, and Misery Camp)	Low	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts for the annual averaging period. The incremental lifetime cancer risks predicted for chromium are greater than the target cancer risk of 1×10^{-5} for the Construction Case and Application Case at Diavik Camp, Ekati Camp/Admin, and Misery Camp. However, the incremental risks as a result of the Project during construction and operations are below the target cancer risk. In addition, the assumption that 100% of the chromium is present is chromium (VI) (assumed due to the lack of speciation data) is likely an overestimate, with the proportion of chromium (VI) likely to be less than 50%.	Not significant	The mitigation recommended for particulate matter will address long-term exposure to chromium [a]
All COPCs	All Other Receptor Locations Evaluated	Negligible	• Air quality concentrations were predicted using maximum emission rates for the Project. The air quality modelling was based on the assumption that most equipment will be operating continuously at maximum capacity, which is an assumption that can lead to an overestimation of the potential Project impacts for the annual averaging period. The predicted peak annual concentrations at the remaining receptor locations were below chronic thresholds, and therefore, health effects as a result of long-term (annual) exposure as a result of the Project are not anticipated.	Not significant	No

DOMINION DIAMOND

Table 7.2-1 Significance of Predicted Risks to Human Health from Inhalation Exposure for the Construction Case and Application Case

Constituent of Potential Concern (COPC)	Receptors	Magnitude of Risk	Conservatism and Rationale	Residual Effects Conclusion	Mitigation Needed?
Particulate Matter Assessment (Acute – 24 Hours)					
PM_{10}	Worker Camps (Diavik and Misery Camp)	Uncertain[e], likely low	• Conservatism in the air quality modelling (e.g., use of the maximum emission rates, assumption that all equipment will be operating continuously at maximum capacity), means that predicted concentrations are likely to have been overestimated. Monitoring for actual particulate matter levels may be warranted to determine whether the predicted concentrations will be realized.	Not significant [d]	Yes
$PM_{2.5}$	Worker Camps (Diavik and Misery Camp)	Uncertain[e], likely low	• Conservatism in the air quality modelling (e.g., use of the maximum emission rates, assumption that all equipment will be operating continuously at maximum capacity), means that predicted concentrations are likely to have been overestimated. Monitoring for actual particulate matter levels may be warranted to determine whether the predicted concentrations will be realized.	Not significant [d]	Yes
PM_{10}	MPOI	Uncertain[e], likely low	• Conservatism in the air quality modelling (e.g., use of the maximum emission rates, assumption that all equipment will be operating continuously at maximum capacity), means that predicted concentrations are likely to have been overestimated. In addition, the assumption that receptors will spend a significant amount of time at the MPOI is overly conservative given that it is not located at any of the sensitive receptor locations identified for the Project. Monitoring of the receptor locations which are close to the MPOI may be warranted to determine actual particulate matter levels.	Not significant [d]	No
$PM_{2.5}$	MPOI	Uncertain[e], likely low		Not significant [d]	No
PM_{10} / $PM_{2.5}$	All other locations evaluated [c]	Uncertain[e], likely negligible	• Conservatism in the air quality modelling (e.g., use of the maximum emission rates, assumption that all equipment will be operating continuously at maximum capacity), means that predicted concentrations at locations where workers may be present are likely to have been overestimated.	Not significant	No

a) Mitigating the generation of road dust would also result in a reduction in metal concentrations in ambient air, as the primary emission source (>85%) of several metals (aluminum, chromium, iron, and manganese) is road dust.
b) Exceedances of acute exposure limits at the MPOI are not considered to be significant.
c) Remaining receptor locations include the following: Courageous Lake Lodge, Diavik TK Camp, Ekati Camp/Admin, Lac de Gras winter road rest stop, LDG hunting camp, Pellatt Lake Cabin, Salmita airstrip, and Treeline Lodge.
d) Not significant presuming that monitoring at worker camps where receptors are likely to be shows particulate matter levels are not as high as those predicted using conservative assumptions.
e) The current state of research on particulate matter does not provide enough evidence to relate specific health outcomes to isolated sources or factors. See Appendix G for further details on why the specific health effects of particulate matter are uncertain.
MPOI = maximum point of impingement; TK = traditional knowledge, LDG = Lac du Gras; ESA = effects study area; $PM_{2.5}$ = particulate matter with a mean aerodynamic diameter of 2.5 microns or smaller; PM_{10} = particulate matter with a mean aerodynamic diameter of 10 microns or smaller; > = greater than.

7.2.1.1 Human Health Multimedia Risk Assessment

The significance of long-term risks for combined exposures to COPCs in air, water, soil, sediment, plants, fish, and wild game are classified in Table 7.1-2. Justification for assignment of magnitude and degree of conservatism and uncertainty are provided in the magnitude of risk tables presented in Section 5.2.

Table 7.2-2 Significance of Predicted Risks to Human Health from Multimedia Exposure for the Application Case

Substance	Receptors	Magnitude of Risk	Conservatism and Rationale	Residual Effects Conclusion	Mitigation Needed?
Arsenic (as a carcinogen)	Seasonal users (Aboriginal and non-Aboriginal)	High (based on ILCR), minimal project influence (<2% change); likely negligible	• Both the carcinogenic and non-carcinogenic effects of arsenic were evaluated. The non-carcinogenic risk estimates did not exceed the acceptable threshold for hazard quotients. The primary contributor to arsenic exposure was dietary intake (background contribution from market foods), which contributed over 80% of total dose. • Contribution of the Project was very low; however, with an increase in cancer risk of less than 2% from Base Case to Application Case, and the Project only risk estimates (Application Case minus Base Case) are considered acceptable for all receptors evaluated. Furthermore, the estimated arsenic exposure for the seasonal receptors is at the low end of the range of background exposure for the general Canadian population, and is much lower than the background exposure observed near point sources (Government of Canada 1993). • Therefore, the overall magnitude of risk from the Project is considered likely negligible and not significant based on the conservatism in the assessment, the minimal project-related effects, and comparison to average Canadian exposure to arsenic.	Not Significant	No
Inorganic Mercury	Seasonal users (Aboriginal toddlers and children)	Low and likely negligible	• The risk estimate for inorganic mercury was only marginally greater than the threshold of 1.0 (HQ = 1.3 for toddlers). The exposure to inorganic mercury was primarily through the consumption of fish, which contributed 94% of total dose. The RfD for mercury is considered very conservative as it was derived using an uncertainly factor of 1,000, and is similar in magnitude to the RfD for methyl mercury, which is considered the more toxic of the two forms of mercury. The assessment also assumed that toddler and children consumed 100% of their fish from Lac du Sauvage and Lac de Gras throughout the entire year, which is very conservative given that people were only assumed to access the ESA area seasonally for fishing and hunting activities. In addition, there was minimal impact related to the Project, and Project only risk estimates (Application Case minus Base Case) are considered acceptable for all receptors. Risk estimates for methyl mercury were considered acceptable for all receptors. • Therefore, the overall magnitude of risk from the Project is considered not significant.	Not Significant	No

Table 7.2-2 Significance of Predicted Risks to Human Health from Multimedia Exposure for the Application Case

Substance	Receptors	Magnitude of Risk	Conservatism and Rationale	Residual Effects Conclusion	Mitigation Needed?
Selenium	Seasonal users (Aboriginal toddlers)	Low and likely negligible	• Application Case HQs only marginally exceeded the threshold of 1.0 (HQ = 1.2 for toddlers). The exposure to selenium was primarily due to dietary food (background contribution from market foods) intake, which contributed nearly three quarters of total dose. Exclusion of background intake altogether results in an acceptable risk (HQ of 0.3). Other sources of conservatism include prediction of concentrations in environmental media (based on conservative assumptions) and use of chronic TRVs for seasonal exposure. In addition, there was minimal impact related to the Project, and Project only risk estimates (Application Case minus Base Case) were considered likely negligible for all receptors. • Therefore, the overall magnitude of risk from the Project is considered not significant.	Not Significant	No
Arsenic (as a non-carcinogen); Chromium; Methyl mercury	Seasonal users (Aboriginal and non-Aboriginal)	Negligible	• Risk estimates were below their respective targets for all receptors, despite the high level of conservatism employed throughout the assessment.	Not Significant	No

ESA = effect study area; HQ = hazard quotient; ILCR = incremental lifetime cancer risk; RfD = reference dose, TRV = toxicity reference value; < = less than.

7.2.1.2 Wildlife Risk Assessment

The potential magnitudes of chronic risks to wildlife from combined exposures to COPCs in aquatic pathways are summarized below. The relative magnitudes of risk for chromium, the only COPC with an HQ greater than 1.0 is discussed in Table 5.3-3.

Arsenic, Mercury, and Selenium

- Magnitude of long-term risk to caribou from these COPCs are predicted to be negligible based HQs<1 for both the Base Case and the Application Case.
- Magnitude of long-term risks to aquatic-feeding wildlife from these COPCs are predicted to be negligible based on HQs<1 for both the Base Case and the Application Case.

Chromium

- Magnitude of long-term risks to caribou are predicted to be negligible based on HQs<1 for both the Base Case and the Application Case.
- Magnitude of long-term risks to aquatic-feeding wildlife are predicted to be negligible based on HQs<1 for both the Base Case and the Application Case.
- The only receptor with HQ greater than one (1) is the semi-palmated sandpiper. The magnitude of long-term risk to sandpiper is low and likely negligible given the small increase from Base Case to Application Case (from 1.4 to 1.5) and conservatism in the assessment (refer to Table 5.3-2)

There were no other COPCs (aside from arsenic, chromium, mercury, and selenium) for caribou and aquatic-feeding wildlife meaning that risks to these receptors from other constituents are predicted to be negligible. There were no COPCs for terrestrial-feeding wildlife meaning that risks from all constituents considered in the wildlife health assessment are predicted to be negligible.

The residual effects conclusions for wildlife health for the Application Case are summarized Table 7.2-3. These residual effects conclusions reflect the combination of potential magnitude of response (as summarized in Section 5.3 and the above bullets) along with assessment of the various uncertainties and conservatism in derivation methods. The results of the multimedia wildlife health assessment indicated that the residual effects of the Project to barren-ground caribou and other wildlife receptors (considering cumulative effects of the Project plus existing Ekati and Diavik mines) are not significant.

Table 7.2-3 Significance of Predicted Risks to Wildlife Health for the Application Case

COPC	Receptor	Magnitude of Risk	Conservatism and Rationale	Residual Effect Conclusion	Mitigation Needed?
All COPCs	Barren-ground caribou	Negligible (all predicted HQs less than 1)	• High – The receptor and exposure assumptions were conservatively derived, and overall reflect overestimates of exposure. The toxicity reference values also are likely to overstate responses expected under field exposures based on bioavailability considerations.	Not significant	No
Chromium	Semi-palmated sandpiper	Low and likely negligible (small increase from Base Case to Application Case)	• High – Exposure for the semi-palmated sandpiper is largely comprised of baseline exposure; the estimated incremental increase in HQ due to the Project is very low (~0.1). These incremental increases are due to assuming that the maximum predicted deposition rate occurs continuously throughout the Project, which is an overestimate of actual emissions and potential changes to water quality (and associated food items consumed by the semi-palmated sandpiper). • The TRVs for chromium are based on highly soluble forms which likely to overstate bioavailability to sandpiper for which the pathway of concern is sediment ingestion from which the bioavailability of chromium would be expected to be less.	Not significant	No
Arsenic, methyl mercury, selenium	Semi-palmated sandpiper	Negligible (all predicted HQs less than 1)	• High – The receptor and exposure assumptions were conservatively derived, and overall reflect overestimates of exposure. The toxicity reference values also are likely to overstate responses expected under field exposures based on bioavailability considerations.	Not significant	No
All COPCs	All other aquatic-feeding wildlife receptors	Negligible (all predicted HQs less than 1)	• High – The receptor and exposure assumptions were conservatively derived, and overall reflect overestimates of exposure. The toxicity reference values also are likely to overstate responses expected under field exposures based on bioavailability considerations.	Not significant	No

COPC = constituent of potential concern; HQ = hazard quotient; TRV = toxicological reference value; ~ = approximately.

7.2.1.3 Residual Effects Summary

Table 7.2-4 summarizes the overall assessment conclusions for human health (air quality [short and long term air quality including particulate matter], multimedia) and wildlife health (multimedia).

Table 7.2-4 Summary of Residual Effects Conclusions for Human Health and Wildlife Health.

Potential Effect	Project Phase Effect Occurs In	Contributing Project Activity	Proposed Mitigation	Residual Effect
Human Health – Air Quality	Construction Case and Application Case (Operations)	Project activities contributing to emission of constituents to air.	• Frequent watering of the haul roads; • Management of vehicle speeds near worker camps (i.e., lower vehicle speeds); • Installation of filters on heating and ventilation air conditioning systems at the worker camps; • Closing of worker camp doors and windows during construction and operation activities; • Confirmation that a Health and Safety Plan for workers covers the mitigation of exposure of workers to dust and particulate matter (this could include personal monitoring for dust levels to confirm exposure predictions).	Not significant
Human Health – Multimedia	Application Case including construction, operations and closure.	Project activities contributing to deposition of particulate matter to terrestrial environments; and emission of substances to aquatic environments.	• None	Not significant
Wildlife Health - Multimedia	Application Case including construction, operations and closure.	Project activities contributing to deposition of particulate matter to terrestrial environments; and emission of substances to aquatic environments.	• None	Not significant

7.2.1.4 Mitigation and Monitoring – Particulate Matter

Appendix A summarizes the potential sources of particulate matter from the Project operations. Sources of particulate matter include unpaved roads in the area as well as drilling, blasting, material movement, and storage. With respect to dust control, the largest emissions from the Project are transport related. During dry seasons, the particulate matter generated by roads can be mitigated by frequent watering of the haul roads and/or application of dust suppressants. Particulate concentrations from transport can generally be expected to be lower in the fall and winter than in the spring and summer when the snow melts and it is drier. In addition, vehicle speed will be managed to limit dust production. Mitigation measures to reduce dust migration into offices and accommodation can also be considered.

In order to protect worker health, further monitoring of particulate matter concentrations during the construction and operations phases of the Project might be useful to capture real (i.e., measured) concentrations as current data are based on conservative modelling. This monitoring is a likely extension of the worker health and safety and worker hygiene programs that are already in effect at the Ekati Mine as regulated under the (NWT) Mine Safety Act.

The predicted particulate matter concentrations are very conservative (conservatism in the particulate matter predictions is discussed in Section 7.2.1). It is also unlikely that people will spend extended periods adjacent to the Project boundary. However, predicted concentrations of particulate matter do exceed screening guidelines at two of the worker camps (Diavik Camp and Misery Camp), and predicted concentrations of some metal COPCs (most of which are related to road dust, the primary source of particulate matter) also exceed screening thresholds (i.e., 1-hour aluminum concentrations at Misery Camp, and annual chromium concentrations at the three worker camps) in air. Therefore, further investigation may be warranted to protect workers.

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