HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT FOR THE HISTORIC KENO HILL MINE SITE, YUKON

Prepared For:

Access Consulting Group

Prepared By:

SENES Consultants Limited

May 2011

SENES Consultants Limited

Specialists in Energy, Nuclear and Environmental Sciences

FINAL

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EXECUTIVE SUMMARY

A Human Health and Ecological Risk Assessment (HHERA) for exposure to contamination at the historic Keno Hill Mine site, Yukon, was carried out to support the "Reclamation Plan for the Existing State of the Mine" being developed by Elsa Reclamation and Development Company Ltd. (ERDC).

Site Description

The historic Keno Hill Mine site is located approximately 330 km north of Whitehorse, Yukon. It comprises approximately 23,350 hectares (ha) of mining leases, quartz claims and crown grants and has numerous mineral occurrences, deposits and prospects, including 35 mines with a history of production. Mining activities at the site ceased in 1989; however, in February 2006, Alexco Resource Corp. (Alexco) obtained 100% ownership of the assets through its wholly-owned subsidiary, Elsa Reclamation & Development Company Ltd.

The surrounding environment continues to be impacted by mine drainage water from abandoned adits, buildings/structures, several tailings impoundment areas and other waste material. The tributaries that drain the properties include Christal Creek, Flat Creek and Lightning Creek and represent the most significantly impacted areas, although some influence on water and sediment quality has been documented further downstream in the South McQuesten River. The Elsa tailings cover an area of approximately 118 ha within the Flat Creek valley bottom and lie approximately 13 km away from the small community of Keno City, which has a resident population of approximately 15 in the summer and 6 in the winter. The tailings are composed of an older and a newer deposit; the older is characterized by high levels of zinc, lead, and copper, while the newer deposit has a different mineral composition and finer particles as a result of improved processing techniques and a different ore body. A second tailings pile, the Mackeno tailings, lies adjacent to Christal Lake.

Available Data

A series of aquatic and terrestrial environmental assessment reports are available, documenting environmental monitoring data and site conditions. The aquatic environment of the Keno Hill area has been described extensively in several reports, from 1985 through to 2010. Data have been collected from various locations, but have focused on Christal Creek, Flat Creek, Lightning Creek and South McQuesten River. Fisheries investigations have evaluated relative fish abundance and community composition, fish habitat, and metal uptake in fish tissue from 1996 to 2009 and some studies have focused on fish barrier investigations to determine the nature and extent of fisheries usage in several of the local creeks. A total of three Terrestrial Effects Assessments reports have been prepared investigating the extent of metal dispersion from the

Elsa tailings into the surrounding terrestrial ecosystem. In general, data from 2000 to 2010 were used in the risk assessment to evaluate the current conditions at the historic Keno Hill Mine site.

Methodology

The risk assessment was undertaken for the purpose of determining whether there are constituent levels present in various media (soil, sediment, surface water, vegetation, fish) that may have an adverse effect on humans or animals that either use, or may potentially use the site or the environment. The assessment included the following steps, which are consistent with those provided by regulatory agencies such as Health Canada and the Canadian Council of Ministers of the Environment (CCME):

- problem formulation and receptor characterization;
- exposure assessment;
- hazard assessment; and
- risk characterization.

A screening process was carried out to develop a list of Constituents of Potential Concern (COPC) at the historic Keno Hill Mine site for a detailed evaluation. Antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium zinc and zirconium were selected as COPC. The assessment was based on reasonable maximum likely exposures to these COPC.

Since the historic Keno Hill Mine site covers a large area with different areas of concern, the site was divided into different exposure locations in order to determine which areas may pose the greatest concern to human and ecological health.

Receptor characteristics (e.g., proportion of time spent in the study area, source of drinking water) and exposure pathways (e.g. inhalation and ingestion) were taken into consideration. For the ecological assessment several different pathways were considered that are linked to either the aquatic environments that may be effected by the site (e.g., Lighting Creek, Christal Creek, Flat Creek, South McQuesten River, etc.) and/or the terrestrial environment including the historic Keno Hill Mine site and surrounding areas. For the human health assessment, individuals were considered to be present at two areas at the site, Galena Hill and the South McQuesten River. Keno City and its residents occupy the shoulder of Keno Hill and there are therefore year-round residents in the vicinity of Galena Hill.

The human health risk assessment was conducted according to Health Canada guidance on Detailed Quantitative Risk Assessments (DQRA [Health Canada 2009a]) while the ecological risk assessment was carried out using the framework as provided by the Canadian Council of the Ministers of the Environment (CCME 1996). The assumptions made for the risk assessment are intended to err on the side of caution and therefore likely result in over-estimated intakes. The level of caution in these assumptions is consistent with the approach typically adopted in risk assessments (Health Canada 2009a).

Aquatic Assessment

The aquatic assessment was conducted for a total of 12 exposure locations (including background), which were selected based on water and sediment data availability and to provide a variety of possible exposure scenarios for evaluation.

The results of the aquatic environment assessment indicated that concentrations of copper, iron, lead, manganese, silver and zinc result exceed toxicity reference values for fish at a number of locations. Christal Creek at the Outlet of Christal Lake and the Lower South McQuesten River are the areas of exceedances for most of the COPC. Zinc concentrations exceed toxicity reference values at most of the locations. It should be noted that zinc concentrations also exceed the toxicity reference values at the background locations. However, the results of the aquatic assessment support that zinc is a key constituent of concern in the aquatic environment. Zinc levels in fish tissue are elevated in most of the mining affected waters. For example, sculpins from the Keno Hill area have zinc levels much greater than sculpins captured near the tailings discharge area at the Faro Mine site. However, fish studies have found that there are no clear differences in overall fish species diversity between mine-exposed and reference areas since average relative fish abundance at all mine-exposed creeks and areas downstream of the South McQuesten River were similar to or higher than the reference area. Thus, the elevated COPC levels in the water bodies in the Keno Hill area are not adversely affecting fish populations.

Sediment toxicity benchmarks are exceeded for arsenic, cadmium, lead and zinc at all locations that were evaluated (Lightning Creek, Christal Creek at outlet and downstream of Christal Lake, Upper and Lower South McQuesten River). Arsenic and cadmium sediment concentrations at background locations also exceed sediment toxicity benchmarks. Although the sediment toxicity benchmarks have been exceeded at South McQuesten River and Lightning Creek, benthic community surveys have reported healthy communities in these two locations. Low numbers and diversity have however been documented in Flat and Christal Creeks suggesting that the high concentrations of COPC in sediments in these two creeks may be adversely affecting benthic communities.

Terrestrial Assessment

An assessment was also carried out for ecological receptors present in the terrestrial environment. As indicated above, the site was divided up into several different areas. The receptors that were considered were avian species such as grouse and waterfowl, small mammalian species such as beaver (aquatic-based diet), fox, hare, marmot and mink(aquatic-based diet), and larger mammals such as bear, caribou, moose, sheep and wolf. The larger animals were evaluated on a site-wide basis while smaller animals were assumed to be present at various locations across the site.

The findings of the assessment indicate that there are no issues for large mammals that are present at the site. Waterfowl that consume mainly benthic invertebrates and sediments (scaup) as well as beaver may be exposed to elevated levels of arsenic, lead and selenium from Christal Creek and Christal Lake. However, populations of these species will not be adversely affected due to the small spatial area. The maximum measured concentration of cadmium in browse results in unacceptable exposures for beaver and hare at the Mackeno Tailings area. Only four samples were collected with cadmium concentrations ranging from 0.31 to 16.6 mg/kg ww. The large range suggests that more browse data may be needed to verify the results of the assessment. Nonetheless, it is not expected that beaver and hare populations would be adversely affected by the elevated cadmium concentrations in browse due to the small spatial extent of the Mackeno Tailings area.

Human Health Assessment

A human health assessment was carried out for hypothetical individuals being present at Galena Hill and the South McQuesten River area. Individuals were assumed to be present in these areas for 1.5 months of the year and hunt, trap, gather and fish and consume the food obtained over a six month period. Different life stages were evaluated ranging from a toddler to an adult.

The results of the assessment indicated that transfer factors used to determine arsenic and zinc concentrations in moose may be over predicting moose tissue concentrations. Measured arsenic concentrations in liver and kidney of moose from the Keno Hill area are similar to those from the Faro Mine site; however the predicted zinc and arsenic concentrations in muscle tissue are 9 to 45 times higher than the measured concentrations in muscle from the Faro Mine site. Therefore it is recommended that moose muscle samples be collected from the area and analyzed to verify the results of the risk assessment. In addition, the assessment demonstrated that consumption of cadmium in moose organs can potentially lead to unacceptable exposures and therefore consumption of moose kidneys and livers should only occur on an occasional basis (i.e., one serving of approximately 112 g every month).

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ADI	Acceptable Daily Intake
ATSDR	Agency for Toxic Substances and Disease Registry
BC	Brefault Creek
Bkgd	Background
CalEPA	California Environmental Protection Agency
CC	Christal Creek
CCME	Canadian Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
CL	Christal Lake
COPC	Constituents of Potential Concern
CSA	Canadian Standards Association
CSD	Contaminated Sites Division
CWF	Canadian Wildlife Federation
d/s	Downstream
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
DQRA	Detailed Quantitative Risk Assessment
EC	Environment Canada
EC_x	Effects Concentration (affecting x% of the study population)
Eco-SSL	Ecological Soil Screening Level
EDI	Environmental Dynamics Inc.
ENEV	Estimated No Effects Value
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment

ERDC	Elsa Reclamation and Development Company Ltd.
FC	Flat Creek
FIEC	Field Creek
FNNND	First Nation of Na-Cho Nyäk Dun
GC	Galena Creek
GH	Galena Hill
HC	Health Canada
HEAST	U.S. EPA Health Assessment Report
HHERA	Human Health and Ecological Risk Assessment
HQ	Hazard Quotient
HSW	Husky Shaft SW
IAEA	International Atomic Energy Agency
IARC	International Agency for Research on Cancer
IC_x	Inhibitory Concentration (affecting x% of the study population)
IPCS	International Programme on Chemical Safety
IRIS	Integrated Risk Information System
ISQG	Interim Sediment Quality Guideline
JECFA	Joint FAO/WHO Expert Committee on Food Additives
K_d	Water-to-Sediment Transfer Factor
LC	Lightning Creek
LC_x	Lethal Concentration (lethal to x% of the study population)
LOAEL	Lowest Observable Adverse Effects Level
LOEC	Lowest Observed Effect Concentration
LTAMP	Long Term Aquatic Monitoring Program
MAC	Maximum Acceptable Concentration

MDL	Method Detection Limit
MOE	Ontario Ministry of the Environment
MRL	Minimal Risk Level
MT	Mackeno Tailings
NCC	No Cash Creek
NCEA	U.S. EPA National Center for Environmental Assessment
NCRP	National Council for Radiation Protection
NOAEL	No Observable Adverse Effects Level
NTIS	National Technical Information Service
ORNL	Oak Ridge National Laboratory
PEL	Probable Effect Level
PQRA	Preliminary Quantitative Risk Assessment
pTWI	provisional Tolerable Weekly Intake
RAIS	Risk Assessment Information System
RDA	Recommended Daily Allowance
RfC	Reference Concentration
RfD	Reference Dose
RIVM	National Institute of Public Health and Environmental Protection
SaC	Sandy Creek
SEL	Severe Effect Level
SF	Slope Factor
SI	Screening Index
SLC	Screening Level Concentration
SK	Silver King
SMQ	South McQuesten (area)

SMQR	South McQuesten River
StC	Star Creek
TDI	Tolerable Daily Intake
TF	Transfer Factor
TRV	Toxicological Reference Value
u/s	Upstream
UCLM	Upper Confidence Level of the Mean (95% 1-sided)
UKHM	Keno Hill Mine (entirety of site)
UR	Unit Risk
VT	Valley Tailings
WHO	World Health Organization
WILC	Williams Creek
WMEC	White Mountain Environmental Consulting
WTCWG	World Trade Center Working Group

GLOSSARY

Term	Description
Allometric Scaling	The application of a mathematical relationship based on body weight to an available feed-to-mammal and feed-to-bird transfer factor to derive a value for a biota for which no measured value exists.
Assessment Endpoint	A quantitative or quantifiable expression of the environmental value considered to be at risk in a risk assessment.
Benchmark	A standard by which something can be measured or judged.
Biota	The animal and plant life of a region
Carcinogen	An agent that has the potential to cause cancer.
Cautious	As used in the term cautious estimates, this is considered a pessimistic or an over-estimate of the level, effect or hazard, as the case may be.
Constituent	A substance that has the potential to alter the natural composition of air, water or soil.
Dose	The amount of a substance to which a person or ecological receptor is exposed over some time period. Dose is a measurement of exposure.
Ecological Risk Assessment	The application of a formal framework, analytical process, or model to estimate the effects of human actions(s) on a natural resource and to interpret the significance of those effects in light of the uncertainties identified in each component of the assessment process. Such analysis includes initial hazard identification, exposure and dose-response assessments, and risk characterization.
Environmental Impact	A change in environmental conditions resulting from an action or development, which may be negative, positive, or neutral.
Exposure	The amount of a pollutant (chemical) present in a given environment that represents a potential health threat to living organisms.
Exposure Pathway	The path from sources of COPC via air, soil, water, or food to man and other species or settings.
Hazard	Potential for exposure to radiation, a chemical, or other COPC to cause illness or injury to humans or ecological receptors. Hazard identification of a given substances is an informed judgment based on verifiable toxicity data from animal models or human studies.
Hazard Assessment	Evaluating the effects of a COPC or determining a margin of safety for an organism by comparing the concentration which causes toxic effects with an estimate of exposure to the organism.
Hazard Quotient	The ratio of estimated site-specific exposure to a single chemical from a site over a specified period to the estimated daily exposure level at which no adverse health effects are likely to occur.
Hepatotoxicity	A general term for liver damage.
Human Health Risk Assessment	The evaluation of whether there is likely to be an adverse health effect caused by the potential exposure to COPC in the environment.

Term	Description
Incremental	Increase in a concentration of some chemical or radionuclide over background conditions as a result of human activities.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest concentration or amount of a substance, found by experiment or observation, which cause an adverse effect in a target organism distinguishable from normal (control) organisms of the same species and strain.
Measurement Endpoint	A quantitative summary of the results of a toxicity test, a biological monitoring study, or other activity intended to reveal the effects of a substance.
Modelling	Using mathematical principles, information is arranged in a computer program to model conditions in the environment and to predict the outcome of certain operations.
Morbidity	Occurrence of a disease or condition that alters health and quality of life.
Mortality	Death.
No Observed Adverse Effects Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful effects on people or animals.
Nephrotoxicity	A general term for kidney damage.
Neurotoxicity	A general term for nervous system effects.
Pathway	The physical course a chemical or pollutant takes from its source to the exposed organism.
Pathways Analysis	A method of estimating the transfer of chemicals (e.g., radionuclides released in water) and subsequent accumulation up the food chain to fish, vegetation, mammals and humans and the resulting dose to humans.
Receptor	A human or ecological entity exposed to a COPC released to the environment.
Risk	A measure of the probability that damage to life, health, property, and/or the environment will occur as a result of a given hazard.
Risk Assessment	Qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific COPC.
Toxicological Reference Value	A value/criterion used to judge whether a predicted exposure may potentially have an adverse effect on human and/or ecological species.
Transfer Factor	An empirical value that provides a measure of the partitioning behaviour of a chemical or substance between two environmental media that is used to estimate concentrations in one environmental medium based on concentrations in another.
Trophic Level	The position an organism occupies on the food chain.
Uncertainty	A quantitative expression of error.
Uptake	The process/act by which a chemical enters a biological organism (e.g., inhalation, ingestion by humans, etc.).

1.0 INTRODUCTION

A Human Health and Ecological Risk Assessment (HHERA) for exposure to constituents in the aquatic and terrestrial environments at the historic Keno Hill Mine site, Yukon was carried out by SENES Consultants Limited on behalf of Access Consulting Group. This work will support the "Reclamation Plan for the Existing State of the Mine" being developed by Elsa Reclamation and Development Company Ltd. (ERDC).

This report details the methodology and assumptions and presents the results of the Detailed Quantitative Risk Assessment (DQRA) for the site. The risk assessment was based on reasonable maximum likely exposures to Constituents of Potential Concern (COPC) at the site. It was assumed that people (represented by a variety of age groups) would be on the site for some portion of the year. The assessment was carried out for the site using data and information documented in various environmental assessment reports (Access 2009; EDI 2008, 2009, 2010; Laberge 2005, 2008; Minnow 2008, 2009, 2010a; WMEC 2006).

1.1 RISK ASSESSMENT APPROACH

The use of risk assessment to establish whether a site can be safely used by the most sensitive receptors likely to occupy it involves the application of a staged, formal and reproducible process that incorporates procedures accepted by the regulatory authorities in the jurisdiction within which the study is being undertaken.

The human health risk assessment was conducted according to Health Canada guidance on DQRA (Health Canada 2009a). The DQRA evaluated the probability of adverse health consequences to humans caused by the presence of constituents of concern in the environment. Receptor characteristics (e.g., proportion of time spent in the study area, source of drinking water) and exposure pathways (e.g. inhalation and ingestion) were taken into consideration.

The ecological risk assessment was carried out using the framework as provided by the Canadian Council of the Ministers of the Environment (CCME 1996).

The assumptions made for the risk assessment are intended to err on the side of caution and therefore likely result in over-estimated intakes. The level of caution in these assumptions is consistent with the approach typically adopted in risk assessments (Health Canada 2009a).

1.2 REPORT STRUCTURE

The report has been structured into several sections, each of which describes specific aspects of the DQRA. These aspects include:

Chapter 2 – Site Characterization: This section provides a brief site description, its general environment and describes the issues identified at the site. It also summarizes the concentrations measured in various environmental media from previous site assessments. The COPC are also identified based on maximum measured soil, terrestrial vegetation, sediment and surface water concentrations.

Chapter 3 – Receptor Characterization: This section identifies the ecological and human receptors to be assessed, and describes the receptor-specific characteristics such as body weight, dietary characteristics, etc. It also identifies the pathways of exposure.

Chapter 4 – Exposure Assessment: This section identifies the areas within which each receptor will be evaluated, and presents the concentrations to which the receptors will be exposed. It also summarizes the estimated intakes by each receptor.

Chapter 5 – Hazard Assessment: This section selects the toxicological reference values against which the exposure values are compared. The values, and their justification for their use, are presented.

Chapter 6 – Risk Assessment: This section evaluates the potential risks to the aquatic, terrestrial and human receptors as a result of exposure to the COPC at the site, based on the information presented in Chapters 4 and 5.

Chapter 7 – Summary and Conclusions: This section provides a summary of the conclusions from the HHERA and identifies potential risk management measures that may be implemented to reduce exposure to acceptable levels.

Chapter 8 – References: This section provides references used in the assessment.

2.0 SITE CHARACTERIZATION

This section provides a brief description of the historic Keno Hill Mine site and surrounding area. More detailed information on environmental conditions can be found in previous environmental assessment reports (Access 2009; EDI 2005, 2008, 2009, 2010; Laberge 2005, 2008; Minnow 2008, 2009, 2010a, 2010b, 2010c; WMEC 2006).

2.1 STUDY AREA

The Keno Hill Silver District is located approximately 330 km north of Whitehorse, Yukon, within the traditional territory of the First Nation of Na-Cho Nyäk Dun (FNNND) (Figure 2.1). It comprises approximately 23,350 hectares (ha) of mining leases, quartz claims and crown grants and has numerous mineral occurrences, deposits and prospects, including 35 mines with a history of production. United Keno Hill Mines Limited and UKH Minerals Ltd. were the previous owners of the properties located on and around Galena Hill, Keno Hill, and Sourdough Hill, collectively known as the Keno Hill Mining Property (Minnow 2009). The deposits were mined from 1913 to 1989 from several underground and open pit mines, producing more than 5.37 million tons of silver with average grades of 40.52 ounces per ton of silver, 5.62% lead and 3.14% zinc. Mining ceased in 1989 when falling metal prices fell and environmental standards increased, forcing Keno Hill into bankruptcy. The district remained abandoned for almost 20 years until, in February 2006, Alexco Resource Corp. (Alexco) obtained 100% ownership of the assets through its wholly-owned subsidiary, Elsa Reclamation & Development Company Ltd. Remaining resources are estimated to exceed 1 million tons with grades averaging 31.5 ounces per ton of silver, 3% lead and 2.2% zinc (Alexco 2007).

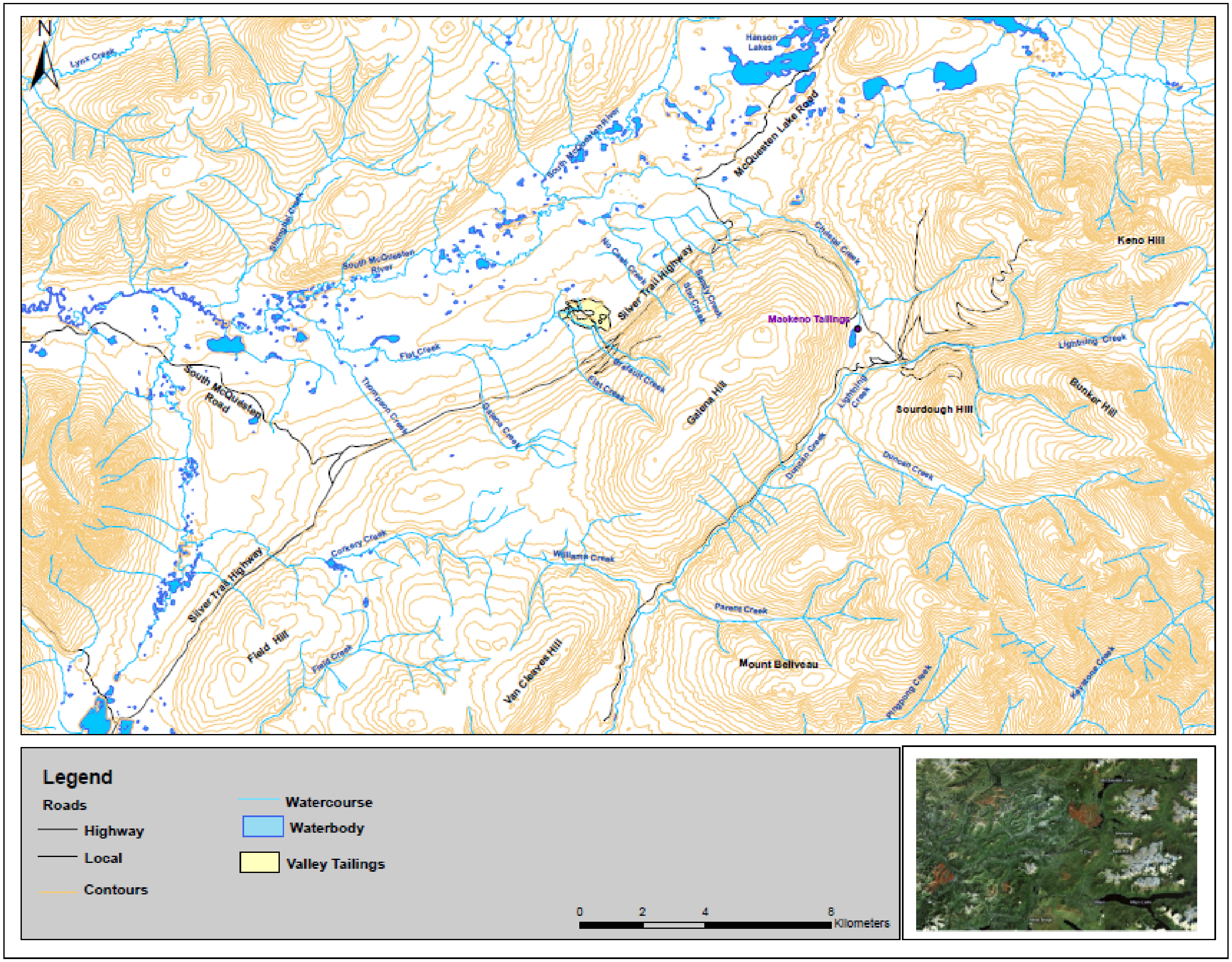
Although mining activities at the historic Keno Hill Mine site ceased in 1989, the surrounding environment continues to be impacted by mine drainage water from abandoned adits, buildings/structures, several tailings impoundment areas and other waste material (Laberge 2008; Minnow 2009). The most significant of these sources include the lime-treated discharge from the tailings pond system and the Galkeno 300 adit, as well as the Galkeno 900, Bellekeno 600 and Silver King adits and the Elsa tailings (Laberge 2008). The tributaries that drain the properties include Christal Creek, Flat Creek and Lightning Creek and represent the most significantly impacted areas, although some influence on water and sediment quality has been documented further downstream in the South McQuesten River (Minnow 2008, 2009 [as cited in Minnow 2010a]). A number of placer mining operations remain active in the area, causing extensive alteration of the watercourses and potential impacts to habitat and water quality downstream (Dan Cornett, Access Consulting, pers. comm.; Pentz and Kostaschuk 1999 [as cited in Minnow 2010a]).

Figure 2.1 Keno Hill Mine Site Location

Notes: Modified from Minnow 2010b

The Elsa tailings lie approximately 13 km away from the small community of Keno City and cover an area of approximately 118 ha within the Flat Creek valley bottom (Figure 2.2). The tailings are composed of an older and a newer deposit; the older is characterized by high levels of zinc, lead, and copper, while the newer deposit has a different mineral composition and finer particles as a result of improved processing techniques and a different ore body (EDI 2008, 2009, 2010). A second tailings pile, the Mackeno tailings, is located adjacent to Christal Lake.

Figure 2.2 Detailed Site Plan



The Keno Hill area has four main water bodies: South McQuesten River, Christal Creek, Flat Creek and Lightning Creek. Christal Creek receives metal-laden inputs from the Galkeno 900 adit, the Galkeno 300 adit and various seepages from workings on the west face of Keno Hill, and also is the receiving water body for Christal Lake which receives wastewater from Galkeno 900 and Mackeno. In addition, there are tailings in the lake that were directly deposited in the past, and the Mackeno tailings pile lies adjacent to the lake. Christal Creek ultimately empties into South McQuesten River, as does Flat Creek which originates on Galena Hill and receives mine effluent from the Elsa Valley tailings facility and various discharges on Galena Hill. Several other smaller tributaries (Galena Creek, Brefault Creek, No Cash Creek, Sandy Creek, Star Creek, Porcupine Creek) originate on Galena Hill, receiving drainages from various adits on and around Galena Hill before emptying into Flat Creek upstream of South McQuesten River. Lightning Creek originates east of the site, flowing just south of Keno City before emptying into Duncan Creek. It receives drainages from various adits on the south side of Keno Hill and the north side of Sourdough Hill, and is also impacted by on-going placer mining activity unrelated to the Elsa/Keno mining developments. Duncan Creek is a tributary of the Mayo River, and both the South McQuesten and Mayo Rivers ultimately drain into the Steward River.

2.2 SUMMARY OF PREVIOUS INVESTIGATIONS

A series of aquatic and terrestrial environmental assessment reports are available, documenting environmental monitoring data and site conditions. The major findings of the assessments are discussed briefly in the following sections.

2.2.1 Aquatic Environment

The aquatic environment of the Keno Hill area has been described extensively in several reports, from 1985 through to 2010 (Table 2.1). Data have been collected from various locations, but have focused on Christal Creek, Flat Creek, Lightning Creek and South McQuesten River. Figure 2.3 provides a summary of the impacted and background/reference stations from where data are available. For clarity, adit and treatment pond stations are not shown.

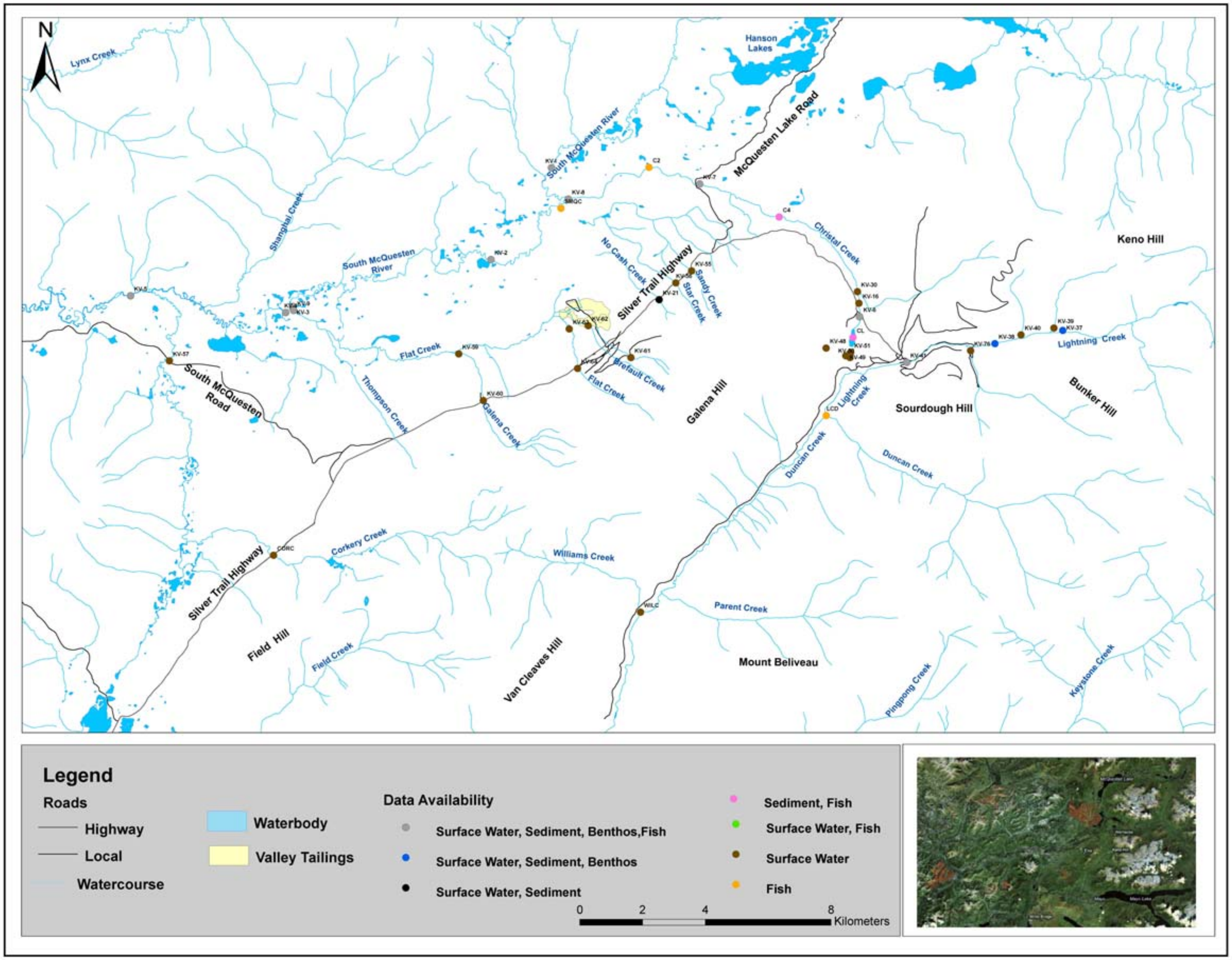
Table 2.1 Summary of Aquatic Environment Reports

Document title	Content	Prepared by	Period covered
Elsa Reclamation and Development Company Keno Hill Mine Keno Hill Silver District Site Investigation and Improvement, Special Projects Fisheries Assessment Project September 17-19, 2008	Investigation into fish presence, fish habitat and metal uptake in fish tissue; fish tissue analysis and comparison to previous data; investigation into barriers to fish movement which exist and may require removal; sediment quality	Access Consulting Group (Access 2009)	2008
Environmental Quality of Receiving Waters at United Keno Hill Mines Ltd., Elsa Yukon	Measurements of water (flow, metal concentrations and general water chemistry), sediment (particle size, metal concentrations) and benthos (population)	Davidge and Mackenzie-Grieve (1989)	1974-75 & 1980 & 1985
South McQuesten Water Quality Sampling Program - Year 2	Water quality results from four sampling periods to capture seasonal variation, and development of natural background levels of metals.	Environmental Dynamics Inc. (EDI 2005)	2004-2005
Keno Valley Receiving Water Monitoring Program, 2004/2005	Investigation of hydrology (water level, flow, basins characteristics), water quality (metals and general chemistry) and sediment quality (metals)	Laberge Environmental Services (Laberge 2005)	2004-2005
Keno Valley Stream, Sediment and Benthic Invertebrate Monitoring Programs, 2007	Measurements of sediment quality (metals) and benthos (population) parameters	Laberge Environmental Services (Laberge 2008)	2007
Water Quality Assessment Report for United Keno Hill Mines	Assessment of the existing water quality data from impacted rivers and creeks as well as background stations	Minnow Environmental Inc. (Minnow 2008)	Historical (1994-2007)
Aquatic Resource Assessment Report for United Keno Hill Mines	Summary of water quality from the area from 1994 through to 2007, assessment of sediment quality data from impacted and background stations, and evaluation of data from recent benthic community and fish surveys and comparison to results from previous studies.	Minnow Environmental Inc. (Minnow 2009)	Historical (Water [1994-2007], sediment [1985, 1994, 2004, 2007] , benthos [1985, 1994, 2007], fish [1994/1995, 2006])

Table 2.1 Summary of Aquatic Environment Reports (Cont'd)

Document title	Content	Prepared by	Period covered
Analyses of Invertebrate and Sediment Data for the Keno Hill Mine Water License (QZ06-074)	Scope of monitoring (sample types, substances, sampling frequency and locations) and reporting requirements for sediment quality and benthic community monitoring in support of water license	Minnow Environmental Inc. (Minnow 2010a)	2009
Long-Term Aquatic Monitoring Program for United Keno Hill Mines	Identification of the requirements for a comprehensive, site-wide long-term aquatic monitoring program to be developed in support of the environmental assessment, closure planning, and regulatory processes in the short-term	Minnow Environmental Inc. (Minnow 2010b)	Historical, and 2009
Approach for Developing Water Quality Goals for United Keno Hill Mines	Review of water quality at Keno Hill Mine site to develop water quality goals for Christal and Flat Creeks and to confirm best approach for water quality assessment in the South McQuesten River	Minnow Environmental Inc. (Minnow 2010c)	Historical
Fish and Fish Habitat Assessment Conducted Near Elsa, Yukon for United Keno Hill Mines August 1994 – September 1995	Fisheries investigation (population, heavy metals in tissue), and habitat availability and utilization by fish	White Mountain Environmental Consulting (WMEC 1996)	1994-1995
Fisheries Assessments Conducted in the Keno Hill Mining Area, Including Metals Analysis of Fish Tissue Samples	Fish habitat, fish utilization and metal content of fish flesh	White Mountain Environmental Consulting (WMEC 2006)	2006

Figure 2.3 Summary of Aquatic Environment Sampling Locations



2.2.1.1 Surface Water

Surface water quality measurements are available as far back as 1974 (Davidge and Mackenzie-Grieve 1989); however, data pre-1994 is inferior and in many cases of dubious quality, largely as a result of higher method detection limits (MDLs) (Minnow 2008). As such, only reports that were prepared post-1994 are discussed in detail here.

In 2004/2005, Laberge (2005) conducted an assessment of the receiving waters of the historic Keno Hill Mine site including South McQuesten River, Christal Creek, Flat Creek and Lightning Creek. The study found elevated levels of zinc in water in the South McQuesten River downstream of Christal Creek. At the time of the study, Galkeno 900 was being lime treated, and Galkeno 300 had recently commenced lime treatment. Fugitive flows from the recently treated Galkeno 300 adit were believed to be the reason for the spike in the zinc concentration, since there appeared to be a general decline in metal concentrations with time.

During the 2007 sampling program (Laberge 2008), cadmium and zinc levels exceeded the CCME guidelines for all drainages and at the reference location KV-1. Copper concentrations were also above the guideline value along Flat Creek and in South McQuesten River, including the reference location KV-1, but not in Christal and Lightning drainages. The higher concentrations measured at KV-1 have been attributed to flow into the river from Cache Creek, which is impacted by natural acid rock drainage in the Cache Creek watershed (EDI 2005).

Minnow prepared a water quality assessment report in 2008 (Minnow 2008) in which water quality data from 1994 through to 2007 were summarized for impacted rivers and creeks as well as background stations upstream of mine-related inputs and disturbances. For several parameters including aluminum, cadmium, copper, iron, phosphorus, sulphate and zinc, the upper range of the background concentrations exceeded the protection of aquatic life guidelines. Many constituents were found to exceed the guideline or the background for at least 10% of the samples at various stations downstream of Keno Hill Mine sources. The concentrations of aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, nitrite, selenium, silver, sulphate and zinc were found to exceed the guideline and background values in at least 50% of the samples. Typically, these exceedances occurred at sampling stations located immediately downstream of mine sources (e.g., adit discharges). The median concentration did not exceed the guideline or the background at the South McQuesten River. The key constituents of concern at the historic Keno Hill Mine site were identified as cadmium and zinc (Minnow 2008). Statistically significant decreases in zinc concentrations were indicated at most stations, particularly from 2004 to 2006 between KV-29 (source water from Galena 300 adit) and KV-30 (downstream of KV-29 in Christal Creek) as a result of remediation and treatment of this adit. Concentrations of cadmium and zinc in the South McQuesten River were below levels of concern based on a review of toxicity literature.

After a review of available aquatic resource assessment reports, Minnow (2009) concurred that concentrations of cadmium and zinc in the portions of tributaries receiving mine drainage (particularly Christal Creek) are at levels that are potentially toxic to aquatic biota, while the concentrations are below levels of concern in the South McQuesten River.

2.2.1.2 Sediment

The sediment quality in the area has been explored several times since 1985 in Lightning Creek, Christal Creek, Flat Creek and South McQuesten River. Over the years there have been variations in the constituents analyzed, laboratory technique and sampling locations. The most relevant variations are the procedural changes as to how the sediment samples were handled prior to analysis. In 1985, the sediment samples were frozen prior to analysis whereas all samples post-1985 were kept cool, not frozen, prior to analysis (Minnow 2009). The 1994, 2004 and 2007 samples were assumed to be oven-dried before analysis (Minnow 2009) while the 1985 samples were freeze-dried (Davidge, pers. comm. [as cited in Minnow 2009]). Sampling from all previous investigations has been on the fine fraction of sediments, and not whole sediments. This tends to result in increased sediment concentrations, and makes comparison to guidelines less straightforward since sediment quality guidelines apply to whole sediments (Minnow 2010a).

In the 2004/2005 receiving water study by Laberge (2005), sediment quality appeared to have improved significantly since the last sampling program in 1997. However, several of the metals were still present at concentrations exceeding the Probable Effect Levels (PELs) for aquatic life. It was recommended that benthic invertebrate sampling be conducted in order to determine the effects, if any, of these high concentrations on aquatic life.

In 2007 the stream sediment levels of arsenic, cadmium, lead and zinc levels were high, typically exceeding the PEL for the majority of the site, including the background site KV-1. The arsenic levels were consistently elevated for all sample sites downstream of Keno Hill Mine sources, and the concentrations were found to be up to 34 times greater than the PEL (Minnow 2009). Flat Creek, KV-9, had the highest documented metal concentrations during the 2007 study. Historically the metal concentrations in sediment have been higher at Flat and Christal drainages then South McQuesten and Lightning drainages (Laberge 2008).

In the 2008 report *Elsa Reclamation and Development Company Keno Hill Mine Keno Hill Silver District Site Investigation and Improvement, Special Projects Fisheries Assessment Project September 17-19, 2008* (Access 2008), seven sediment samples were analyzed, three of which were obtained from Christal Creek around fish barriers, two of which were obtained from the Mackeno tailings deposit adjacent to the outlet of Christal Lake, and two of which were obtained from Christal Lake outlet itself (Access 2008). There was no noticeable difference in the metal levels between the sediment samples taken from the Mackeno tailing deposition and the Christal Lake samples, but the concentrations were higher than those in Christal Creek. The

2007 and 2008 data was found to be consistent for the Christal Creek area with the exception of one sampling site, KV-8. The lead levels had increased from 400-600 mg/kg to 11, 000-24,000 mg/kg (Access 2009).

In 2009, the CCME Interim Sediment Quality Guidelines (ISQGs) and/or PELs were exceeded for arsenic, cadmium, copper, manganese, nickel and zinc concentrations in sediment at both reference and mine-exposed stations, and for lead and iron at all mine-exposed stations (Minnow 2010a). In general the sediment chemistry has not followed a consistent increasing or decreasing trend with time. However, at the reference site KV-1, increases were observed in the cadmium, nickel and zinc concentration over the years while a decrease was observed in the iron concentrations. Due to the increased metal levels at KV-1, a new reference sampling location was added (Minnow 2010b). Concentrations in mine-exposed creeks generally decreased relative to guidelines, with the exception of copper.

2.2.1.3 Fish

Fisheries investigations have evaluated relative fish abundance and community composition, fish habitat, and metal uptake in fish tissue (Access 2009; WMEC 1996, 2006). The 2006 and 2008 studies (WMEC 1996 and Access 2009, respectively) focused on fish barrier investigations to determine the nature and extent of fisheries usage in several of the local creeks. The 2006 study found that fish habitats throughout the study area have changed since 1995 and that fish utilization was lower in most areas. Fish species most common in the area include Arctic grayling, slimy sculpin, burbot, northern pike, long nose suckers, Arctic lamprey, and round whitefish; however, juvenile and spawning populations of Chinook salmon have also been recorded (WMEC 2006). South McQuesten River provides habitat for a variety of fish species, while Christal Creek utilization is relatively low with the exception of a small population of Arctic grayling in the mid section of the creek and populations of slimy sculpin in Christal Lake. Flat Creek provides some habitat within the lower 800 meters of its confluence with the South McQuesten River. Habitats in Lightning Creek have been subject to placer mining influences are generally of poor quality, although Arctic grayling, slimy sculpin and round whitefish have been documented in its lower reaches near Duncan Creek (WMEC 2006).

2.2.1.4 Benthic Invertebrates

The benthic invertebrate community in the South McQuesten River and Duncan watersheds has been investigated several times in the last thirty years. In 1985, 1994 and 2007 artificial substrates were used in data collection (Minnow 2010b). In the 2010 report *Analyses of Invertebrate and Sediment Data for the Keno Hill Mine Water License (QZ06-074)* by Minnow Environmental Inc., differences were observed in the benthic macro invertebrate community composition in the mine-exposed regions of the South McQuesten River for unknown causes (Minnow 2010a). Historically there is evidence of relativity low abundance and numbers of taxa at Flat and Christal Creek as compared to other reference and mine exposed areas. From the observed correlation it was thought that the number of taxa decreased as the metals concentrations in the water and stream sediment increased (Minnow 2009; Laberge 2008). A low confidence in the bioassessment of Flat and Christal Creeks was expressed by Minnow (2010a) in relation to the uncertainty of the appropriateness of the reference area and the absence of replicate samples.

In the 2007 summer monitoring program 54,609 individuals were observed, which were classified into 98 different taxonomic groups under five phyla (arthropoda, mollusca, annelida, nematode, cnidaria). The benthic invertebrate communities were found to be healthy at the South McQuesten River and Lightning Creek drainages, and there was a good representation of highly sensitive insects in the area. A higher but less diverse population was observed at Christal Creek (KV-6) near the outlet of Christal Lake. The populations at KV-9 (Flat Creek) were depressed and the diversity was low, again thought to be as a result of the high concentrations of metals in the sediment (Laberge 2008).

2.2.2 Terrestrial Environment

A total of three Terrestrial Effects Assessments reports have been prepared by Environmental Dynamics Inc. (EDI 2008, 2009, 2010), investigating the extent of metal dispersion from the Elsa tailings into the surrounding terrestrial ecosystem. The objective of the first study, *Elsa Tailings Environmental Effects Assessment - Phase 1* (EDI 2008), was to determine if, and to what extent, aerial dispersion of metals had occurred using lichens as indicators of airborne contamination. The second study, *Elsa Tailings Terrestrial Effects Assessment - Phase 2* (EDI 2009), investigated impacts on plants traditionally harvested and consumed for medicinal purposes by FNNND. Samples were collected from the same locations as in the Phase 1 study (i.e., Elsa tailings), as well as two other areas (Mackeno Tailings and Minto Bridge) to further understand natural properties of plants in and around the area. Minto Bridge was identified as a site used by FNNND for traditional harvesting of medicinal plants. The third study, *Elsa Tailings Terrestrial* Effects *Assessment- Phase 3* (EDI 2010), was a follow up study to determine if the elevated metals concentrations in plants observed in the Phase 2 assessment were due to contamination in the soil, and to gain a superior understanding of the metal concentrations in the area with respect to different disturbances (tailings and point source water discharges) (EDI 2010). Figure 2.4 summarizes the areas of Keno Hill that have been sampled, and identifies which data are available for each area (i.e., soil, vegetation, lichen/moss).

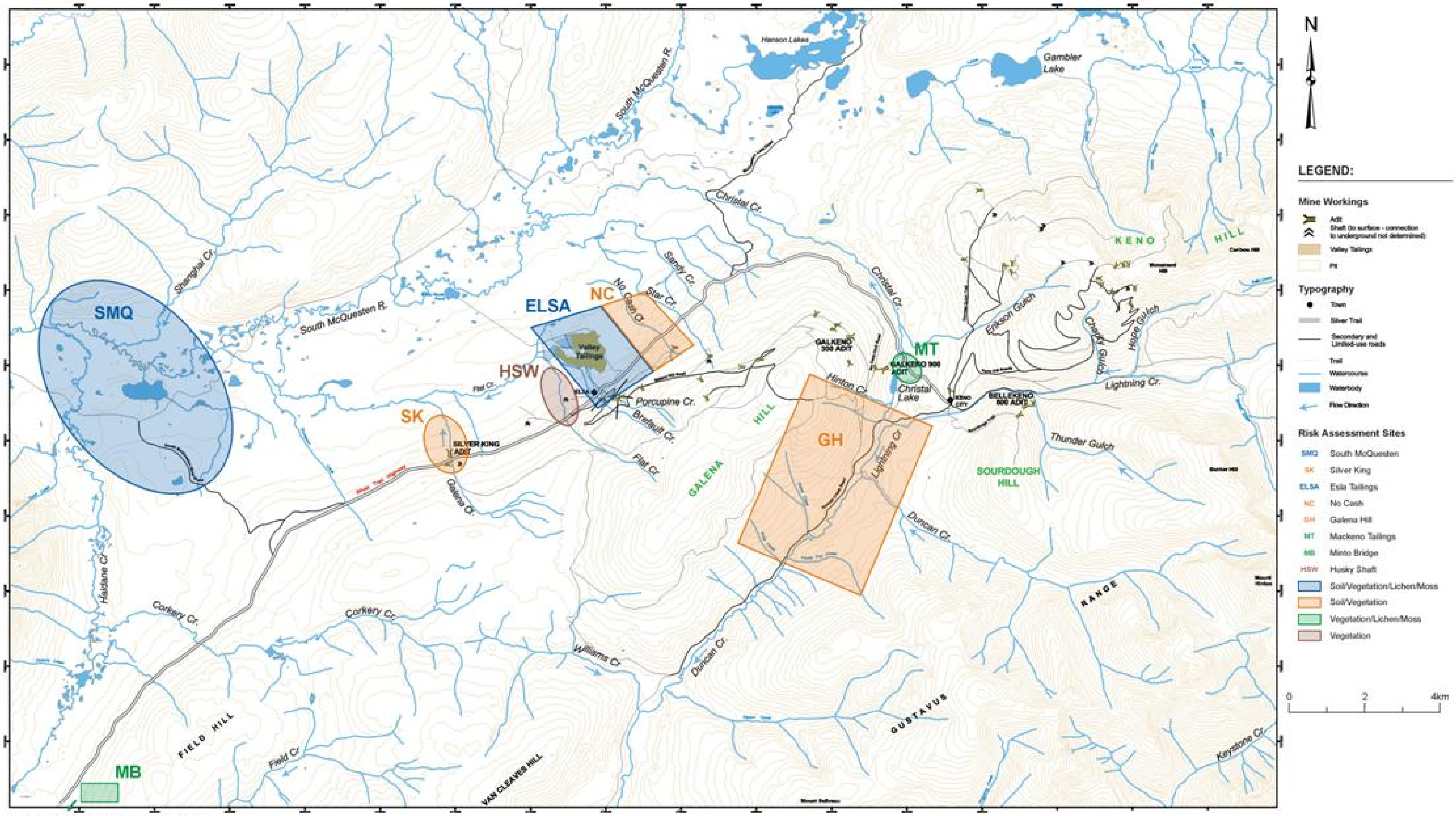
In the Phase 1 assessment, lichen was sampled as it is an excellent indicator of airborne contamination (EDI 2008). The tailing facilities cover approximately 118 ha, which contains both dry tailings in the eastern half and three tailing ponds in the northwest section (EDI 2008). Aerial contamination was indicated but was limited to the area around the eastern 'dry' portion of the tailings facilities. There were concerns regarding the potential for ongoing contamination from dry tailing dust to the adjacent ecosystems (EDI 2008). It was suggested that other components of the terrestrial ecosystem be assessed, particularly plant material and small mammals consumed by FNNND.

In the Phase 2 assessment it was observed that some of the medicinal plants used by FNNND had elevated heavy metal concentrations, particularly those that originated in the Elsa and Mackeno tailings regions (EDI 2009). However, heavy metal concentrations in plants showed variation based on species and portion of plant sampled as a result of varying abilities to uptake metals, related to chemical properties of the metal, physical and chemical properties of the soil, and morphological and physiological characteristics of the plant (Cataldo and Wildung 1978 [as cited in EDI 2009]). The characteristics of the Elsa mine tailings, comprising both new and older deposits, may also have contributed to the variability. Background and control sites showed that iron and zinc do occur naturally in the soils; however, iron and zinc in willow and scrub birch around the Elsa tailings, and zinc in willow and scrub birch around the Mackeno tailings were elevated above background and control levels (EDI 2009).

As part of the Phase 3 assessment, soil and vegetation sampling was undertaken in three areas (point source, tailings, control). Soil samples were collected from two mineral horizons (A and B) and vegetation samples were collected from three shrub species common to the area and used by FNNND (scrub birch, Labrador tea and willow). The metal concentrations were found to be independent of the horizon and disturbance type with respect to the soil samples. It was concluded that the Keno Hill area contained naturally elevated metal concentrations as some samples from all sampling locations exceeded CCME soil quality guidelines (EDI 2010). A clear pattern was observed between the elevated metal concentrations and the sampling location for the vegetation samples. Plants sampled from the control and point source disturbance areas had similar patterns of metal contamination, while vegetation samples from the Elsa tailings had the highest metal concentrations. The metal concentrations appear to be species-specific, with Labrador tea containing the lowest metal concentrations and willow containing the highest. A clear relationship was not observed between the metal concentrations in the soils and plants and it was therefore concluded that the accumulation of metals in tissue was not due to the contaminated soil. EDI suggested that the most likely pathway was aerial deposition of dust from the Elsa tailings (EDI 2010).

As part of the field work conducted under the Natural Attenuation Special Project, a fourth round of terrestrial vegetation sampling was recently conducted (December 2010) around the North face of Galena Hill, around the Silver King adit, Husky Shaft, and No Cash Creek. The study focused on investigating the metal concentrations in vegetation in areas that receive metal laden discharges from adits. This sampling program focused on parts of the vegetation consumed by terrestrial wildlife (i.e., caribou), and not humans (Pelchat, pers. comm. 2011). The results were provided by EDI, but no report was available at the time of preparation of this report.

Figure 2.4 Summary of Terrestrial Environment Sampling Locations



Notes: Map adapted from Minnow 2010b

2.3 SUMMARY OF ENVIRONMENTAL DATA

The data from the above discussed reports are summarised in the following sections for the aquatic and terrestrial environments for all years for which data were available. For all environmental media, values that were reported as non-detects (i.e., below the method detection limit [MDL]) were converted to ½ the MDL before the statistics were calculated.

2.3.1 Aquatic Environment

Measured concentrations of metals from sampling programs conducted in the aquatic environment are available for water, sediment and fish (whole, muscle and liver). The sampling locations were provided in Figure 2.3.

2.3.1.1 Surface Water

Surface water quality data are obtained regularly (generally monthly) from impacted water bodies (i.e., downstream of point sources such as adits), reference water bodies (upstream of point sources), and point sources (adits, treatment/tailings ponds, etc.). A database of measurements from January 1994 through to April 2009 has previously been compiled. In addition, surface water quality was measured at several reference areas in August 2009 as part of the Long Term Aquatic Monitoring Program (LTAMP) for the historic Keno Hill Mine site (Minnow 2010b), and at several areas around Sandy and Star Creeks in September 2009 (Tremblay, pers. comm. 2011); these data were included in the data set. Table 2.2 summarizes water quality data from 1994 through to 2004 for impacted water bodies. Average background concentrations from reference locations are also included in the table. These reference locations include water monitoring stations KV-1, KV-37, KV-57, KV-60, KV-61, KV-64, KV-65, KV-77, FIEC (Field Creek) and WILC (Williams Creek). Although the concentrations at KV-1 have been found to be increasing since 2007 as a result of loads from Cache Creek from natural acid rock drainage in the Cache Creek watershed (EDI 2005), KV-1 is the best reference area for the South McQuesten River downstream of the historic Keno Hill Mine site as it represents the upstream condition prior to Keno Hill Mine site sources (Minnow 2010). Measurements from samples obtained from point sources were removed from the data set since these do not represent water bodies to which human or ecological receptors would likely be exposed. The values in Table 2.2 are for total metals, although measurements have also been reported in the database for dissolved metals.

Table 2.2 Surface Water Summary Statistics

Constituent	Bkgd. Average (mg/L)	N	N<MDL	Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	Std. Dev. (mg/L)
Ammonia	0.02	44	28	0.027	0.11	0.001	0.021
Aluminum	0.29	662	56	0.39	15.3	0.003	1.15
Antimony	0.003	710	254	0.005	0.09	0.0001	0.012
Arsenic	0.011	780	92	0.010	0.18	0.0002	0.018
Barium	0.069	678	5	0.065	0.70	0.0001	0.045
Beryllium	0.0001	678	623	0.001	0.072	0	0.006
Bismuth	0.002	643	621	0.003	0.29	0	0.014
Boron	0.003	571	268	0.004	0.065	0	0.007
Cadmium	0.001	809	45	0.004	0.21	0.00002	0.015
Calcium	49.3	671	1	108	823	0.0001	89.9
Chromium	0.001	678	348	0.32	163	0.0001	6.45
Cobalt	0.002	672	199	0.001	0.05	0.00002	0.004
Copper	0.005	815	209	0.005	0.14	0.0001	0.009
Iron	0.53	795	104	0.90	44.4	0.001	2.89
Lead	0.02	839	78	0.018	1.17	0.0001	0.058
Lithium	0.006	647	61	0.009	0.19	0.001	0.010
Magnesium	13.8	671	1	21.1	184	0.002	15.0
Manganese	0.14	786	32	1.46	121	0.001	7.94
Mercury	0.0001	29	21	0.15	4.40	0.00001	0.82
Molybdenum	0.001	669	543	0.001	0.11	0.00001	0.005
Nickel	0.010	784	60	0.009	0.29	0.0003	0.026
Phosphorus	0.04	191	106	0.068	1.40	0.0003	0.16
Potassium	0.50	652	241	0.52	5.90	0.03	0.42
Selenium	0.004	672	191	0.007	0.50	0.0001	0.028
Silicon	2.85	672	7	3.33	20.4	0.001	1.63
Silver	0.0002	675	439	0.015	3.50	0.000003	0.22
Sodium	1.56	659	23	1.65	8.20	0.0001	0.89
Strontium	0.18	666	0	0.25	1.81	0.01	0.18
Sulphur	24.6	618	1	82.2	791	0.10	90.3
Tellurium	0.00005	77	74	2.09	124	0.00001	14.4
Thallium	0.0001	501	457	0.31	156	0.000001	6.97
Thorium	0.001	182	143	0.001	0.027	0.000003	0.002
Tin	0.001	656	609	0.002	0.076	0.00001	0.005
Titanium	0.01	660	81	0.051	20.7	0.00001	0.81
Uranium	0.01	636	150	0.007	0.19	0.0001	0.014
Vanadium	0.001	665	142	0.002	0.044	0.00002	0.004
Zinc	0.065	823	5	1.21	81.4	0.0001	6.19
Zirconium	0.001	628	559	0.006	3.05	0.0001	0.12

Notes: Data from 1994-2009 (point source measurements not included in data set)
Bkgd - Background locations considered to be KV-1, KV-37, KV-57, KV-60, KV-61, KV-64, KV-65, KV-77, FIEC (Field Creek) and WILC (Williams Creek)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

2.3.1.2 Sediment

Sediment quality was analyzed in 1985, 1990, 1994, 1997, 2004, 2007, 2008 and 2009. These sampling programs generally focused on collecting data from impact stations downstream of point sources such as adits (e.g., KV-2 through to KV-9, KV-38, KV-41) and reference stations (e.g., KV-1, KV-37); the 2008 sampling program, however, focused on evaluating sediment quality at fish barriers along Christal Creek downstream of Christal Lake, and near tailings deposits in Christal Lake. Data are not available for smaller tributary watercourses such as those upstream of adits (e.g., KV-59, KV-60, etc.). Analysis of sediment samples has historically been conducted on the fine fraction, although it has been suggested that future monitoring focus on whole (bulk) sediment analysis (Minnow 2010b). The summary statistics for the fine fraction of sediment samples that have been collected from the Keno Hill area from 1985 through to 2009 are summarized in Table 2.3. The background averages were calculated from measurements from reference locations KV-1and KV-37.

Table 2.3 Sediment Summary Statistics

Constituent	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Aluminum	10190	96	0	8357	17600	598	3192
Antimony	0.87	96	11	66.4	1430	0.25	199
Arsenic	43.0	112	0	681	14100	13.10	2363
Barium	177	96	1	208	633	0.015	111
Beryllium	0.25	96	19	0.20	0.57	0.05	0.11
Bismuth	1.17	96	39	1.78	9.40	0.05	1.73
Cadmium	2.47	117	0	137	4740	0.51	617
Calcium	6408	96	0	9369	55800	894	7234
Chromium	15.1	96	2	15.0	51.4	0.02	7.11
Cobalt	13.7	96	0	13.9	58.4	4.90	9.98
Copper	26.7	117	0	71.0	504	9.80	84.9
Iron	18629	96	0	50373	1280010	12100	133776
Lead	21.3	117	0	1957	23900	18.80	3967
Lithium	12.8	89	0	11.2	24.0	1.30	4.44
Magnesium	4782	96	0	5552	23100	936	2716
Manganese	619	91	3	7368	48500	0.15	12672
Mercury	0.063	44	1	0.47	3.94	0.025	1.05
Molybdenum	1.21	96	23	1.26	7.00	0.025	1.00
Nickel	45.6	96	0	41.6	204	7.50	32.0
Phosphorus	896	117	0	840	1800	112	268
Potassium	494	96	4	611	3170	99.0	496
Selenium	0.95	96	43	1.78	12.1	0.05	2.33
Silicon	224	22	0	273	1000	60.0	170
Silver	0.4	96	1	24.3	360	0.23	56
Sodium	82.0	91	34	100.9	278	1.20	50.2
Strontium	23.1	5	1	28.4	113	0.50	17.7
Sulphur	570	96	0	4245	32100	50.0	7500
Thallium	0.4	22	2	5.4	48.6	0.025	11.5

Table 2.3 Sediment Summary Statistics (Cont'd)

Constituent	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Thorium	4.00	74	10	2.55	7.00	0.50	2.28
Tin	0.35	22	31	3.07	37	0.1	6.88
Titanium	146	96	0	177	803	0.20	154
Uranium	1.3	96	22	13.2	244	0.33	49.3
Vanadium	23.7	89	0	22.8	43.0	2.90	7.37
Zinc	293	96	0	8239	195000	74.0	30308
Zirconium	1.92	117	5	2.85	8.60	0.05	1.70

Notes: Data from 1990, 1994, 1997, 2004, 2007, 2008 and 2009
'-' - No data available
Bkgd - Background locations considered to be KV-1 and KV-37
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

2.3.1.3 Fish

Concentrations of metals in fish are reported in various reports for 1990-1991, 1994, 1995, 2006 and 2008 for fish tissue (flesh/muscle), liver, and whole fish samples. Liver data are only available for a select few heavy metals (arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, zinc) for a few fish samples, while whole fish and fish flesh/muscle data are available for a larger number of constituents and samples. Fish were generally captured from lakes and/or creeks in the immediate vicinity of the historic Keno Hill Mine site; however, historical data are available for a few samples from 1990-1991 and 1995 from water bodies that are further away (i.e., Wareham Lake, Mayo Lake, Aishihik Lake). Statistics are presented for fish liver (Table 2.4), fish tissue (Table 2.5), and whole fish (Table 2.6). Background averages were calculated from measurements in fish captured from reference locations (KV-1, KV-72) and historical data from Wareham, Mayo and Aishihik lakes.

Table 2.4 Fish Liver Summary Statistics

Constituent	Bkgd. Average (mg/kg ww)	N	N<MDL	Average (mg/kg ww)	Maximum (mg/kg ww)	Minimum (mg/kg ww)	Std. Dev. (mg/kg ww)
Arsenic	0.86	5	2	0.68	1.10	0.27	0.38
Cadmium	0.20	5	0	1.12	2.64	0.070	1.35
Chromium	1.80	5	0	2.15	10.1	0.11	4.44
Cobalt	0.72	5	0	0.18	0.35	0.05	0.16
Copper	10.6	5	0	8.39	15.2	4.75	4.36
Lead	0.72	5	1	0.43	0.7	0.14	0.24
Mercury	0.08	5	1	0.068	0.11	0.014	0.046
Nickel	0.17	5	0	0.10	0.14	0.06	0.04
Zinc	33.5	5	0	35.5	67	4.50	22.0

Notes: Data from 1990-1991, 1994, 1995
'-' - No data available
Bkgd - Background samples taken as reference locations (KV-1, KV-72), and Wareham, Mayo and Aishihik lakes
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

Table 2.5 Fish Tissue Summary Statistics

Constituent	Bkgd. Average (mg/kg ww)	N	N<MDL	Average (mg/kg ww)	Maximum (mg/kg ww)	Minimum (mg/kg ww)	Std. Dev. (mg/kg ww)
Aluminum	-	12	2	10.3	49	1.0	16.7
Antimony	-	12	10	0.006	0.01	0.005	0.003
Arsenic	0.59	20	6	0.25	0.93	0.04	0.21
Barium	-	12	0	0.91	2.70	0.40	0.67
Beryllium	-	12	12	0.05	0.05	0.05	0
Bismuth	-	12	12	0.04	0.05	0.02	0.01
Cadmium	0.028	19	3	0.06	0.32	0.008	0.08
Calcium	-	12	0	6462	13600	2310	2788
Chromium	0.26	21	9	0.36	2.5	0.05	0.60
Cobalt	0.074	18	2	0.06	0.16	0.01	0.04
Copper	0.46	21	0	0.51	1.1	0.19	0.20
Iron	-	2	0	52	82	21.7	42.3
Lead	0.26	19	2	0.23	0.7	0.010	0.18
Lithium	-	12	12	0.05	0.05	0.05	0.000
Magnesium	-	12	0	301.9	432.0	115.0	75.2
Manganese	-	12	0	5.4	11	1.03	3.3
Mercury	0.068	9	4	0.040	0.13	0.013	0.042
Molybdenum	-	12	10	0.045	0.32	0.005	0.10
Nickel	0.32	18	10	0.25	1.69	0.05	0.43
Phosphorus	-	2	0	4655	5300	4010	912
Potassium	-	2	0	3065	3230	2900	233
Selenium	-	12	0	1.39	2.98	0.44	0.77
Silver	-	2	0	0.013	0.014	0.012	0.001
Sodium	-	2	0	929	1040	818	157
Strontium	-	12	0	5.51	11.7	1.96	2.6
Thallium	-	12	11	0.006	0.019	0.005	0.004
Tin	-	12	12	0.025	0.025	0.025	0
Titanium	-	2	0	0.99	1.88	0.10	1.26
Uranium	-	12	10	0.0019	0.01	0.001	0.002
Vanadium	-	12	10	0.06	0.14	0.050	0.031
Zinc	17.1	21	0	26.1	54	7.30	14.0

Notes: Data from 1990-1991, 1994, 1995, 2006 and 2008
'-' - No data available
Bkgd - Background samples taken as reference locations (KV-1, KV-72), and Wareham, Mayo and Aishihik lakes
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

Table 2.6 Whole Fish Summary Statistics

Constituent	Bkgd. Average (mg/kg ww)	N	N<MDL	Average (mg/kg ww)	Maximum (mg/kg ww)	Minimum (mg/kg ww)	Std. Dev. (mg/kg ww)
Aluminum	21.2	50	0	29.0	148	3.6	26.3
Antimony	0.007	50	4	0.053	0.33	0.005	0.068
Arsenic	0.15	65	0	1.00	3.95	0.19	0.74
Barium	1.82	50	0	2.18	3.93	0.80	0.83
Beryllium	0.050	50	50	0.05	0.05	0.05	0
Bismuth	0.050	50	50	0.05	0.05	0.02	0.01
Cadmium	0.32	65	0	0.35	1.26	0.036	0.24

Table 2.6 Whole Fish Summary Statistics (Cont'd)

Constituent	Bkgd. Average (mg/kg ww)	N	N<MDL	Average (mg/kg ww)	Maximum (mg/kg ww)	Minimum (mg/kg ww)	Std. Dev. (mg/kg ww)
Calcium	12565	50	0	11105	19400	5450	2936
Chromium	0.065	65	16	0.30	7.8	0.05	0.96
Cobalt	0.21	65	3	0.11	0.73	0.01	0.13
Copper	1.54	65	0	1.05	3.5	0.44	0.44
Iron	-	2	0	154	239	69.2	120.1
Lead	0.062	65	4	3.46	29.4	0.100	5.50
Lithium	0.050	50	49	0.05	0.14	0.05	0.013
Magnesium	375	50	0	350.1	464.0	256.0	42.7
Manganese	20.7	50	0	33.7	118	11.20	21.6
Mercury	-	15	15	0.049	0.13	0.011	0.054
Molybdenum	0.025	50	0	0.047	1.03	0.014	0.14
Nickel	0.76	65	7	0.45	5.29	0.05	0.71
Phosphorus	-	2	0	5870	6340	5400	665
Potassium	-	2	0	2465	2470	2460	7.1
Selenium	1.20	50	0	1.30	3.03	0.41	0.62
Silver	-	2	0	0.023	0.027	0.018	0.006
Sodium	-	2	0	1075	1130	1020	78
Strontium	13.4	50	0	8.51	18.7	2.28	4.6
Thallium	0.005	50	45	0.006	0.019	0.005	0.003
Tin	0.025	50	50	0.025	0.025	0.025	0
Titanium	-	2	0	2.47	4.16	0.78	2.39
Uranium	0.006	50	1	0.0102	0.06	0.001	0.011
Vanadium	0.080	50	23	0.12	0.44	0.050	0.086
Zinc	58.5	65	0	60.9	187	27.00	26.9

Notes: Data from 1994, 2006 and 2008
'-' - No data available
Bkgd - Background samples considered to be reference locations (KV-1, KV-72)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

2.3.2 Terrestrial Environment

Previous environmental monitoring has focussed on the aquatic environment, and it is only in recent years that the terrestrial environment (soil, vegetation) has been evaluated. Figure 2.4 identified the approximate sampling areas.

2.3.2.1 Soil

Soil quality data were provided in a database from EDI and included data from the 2009 sampling program as part of the *Elsa Tailings Terrestrial Effects Assessment - Phase 3* (EDI 2010) as well as 2009 data obtained by Access as part of field work conducted under the Natural Attenuation Special Project. Samples were obtained from the tailings disturbance area directly around the Elsa tailings, two areas potentially impacted by water discharge from mine adits (Silver King and No Cash), and two 'control' areas not known to be influenced by the tailings or adit discharges (Galena Hill and South McQuesten). A few samples were also obtained directly from the Elsa tailings. Six of the samples that were obtained by Access were from an unreported location. Samples were obtained from both the A and B horizons (surface and surficial soils, respectively) and the top organics layer. The summary statistics for the soil data are presented in Table 2.7 for all soil sample types, with the exception of those obtained directly from the tailings (samples Z1, Z2 and Z3) as these do not represent actual soil concentrations. Background averages were calculated from the samples obtained from the Galena Hill and South McQuesten control areas. The data from the unknown location were assumed to be from an impacted area.

Table 2.7 Soil Summary Statistics

Constituent	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Aluminum	6377	81	0	6687	14900	556	3705
Antimony	4.10	81	4	8.94	430	0.05	48.2
Arsenic	45.5	81	0	70.3	3490	2.0	386
Barium	217	81	0	347	3580	7.0	418
Beryllium	0.45	81	36	0.40	0.80	0.05	0.15
Boron	2.85	32	0	3.75	9.0	2.0	2.06
Cadmium	3.73	81	2	12.3	248	0.10	35.7
Calcium	10045	81	0	18442	47800	2860	11890
Chromium	12.2	81	0	13.4	27	3.0	6.68
Cobalt	10.8	81	0	12.2	176	1.0	20.8
Copper	26.6	81	0	47.9	224	14.0	31.3
Iron	18688	81	0	21023	162000	1780	20543
Lead	91.3	81	0	398	26800	1.3	2976
Magnesium	2960	81	0	4356	14700	1110	2331
Manganese	1190	81	0	4450	96000	76.0	13666
Mercury	0.051	81	7	0.094	1.92	0.02	0.21
Molybdenum	1.02	81	0	1.45	15.0	0.1	1.75
Nickel	35.1	81	0	26.0	89.8	6.5	15.1
Phosphorus	729	81	0	788	1540	213	210
Potassium	290	81	0	363	881	22	221
Selenium	1.01	81	9	1.10	7.0	0.2	0.89
Silver	1.82	81	1	5.28	130	0.05	18.8
Sodium	23.9	81	72	34.7	69.0	2.5	21.6
Strontium	35.7	81	0	50.1	153	4.0	27.0
Thallium	0.059	81	40	0.22	5.3	0.025	0.69
Tin	2.31	81	42	1.41	15	0.05	1.91
Titanium	91.5	81	0	115	322	4.0	77.8
Vanadium	18.2	81	0	20.8	43	2.0	11.4
Zinc	353	81	0	962	14800	11.0	2486
Zirconium	1.45	81	10	2.24	18.7	0.5	2.39

Notes: Data from 2009 (from samples taken directly from the tailings (samples Z1, Z2 and Z3) not included in data set)
'-' - No data available
Bkgd - Background locations considered to be undisturbed control areas (Galena Hill and South McQuesten)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

2.3.2.2 Terrestrial Vegetation

Terrestrial vegetation data have been collected during four separate sampling programs (2007 through to 2010), three of which have been discussed in detail in the *Elsa Tailings Terrestrial Effects Assessment* Phase 1, 2 and 3 reports (EDI 2008, 2009, 2010). The data from 2010 were collected in December and a report was not available at the time this report was prepared. The data were provided in two separate database files from EDI for various species. Based on information from community consultation on plant species and portions harvested by the FNNND for medicinal purposes (EDI 2009), and based on the part of the plant sampled, for this assessment the data have been broken down into the following classifications:

- Berries: bog blueberry fruit (*Vaccinium uliginosum*), crowberry (*Empetrum* sp.) and prickly rose fruit (*Rosa acicularis*)
- Browse: alder (*Alder* sp.), paper birch (*Betula papyrifera*), prickly rose (*Rosa acicularis*), scrub birch (*Betula glandulosa*), and willow (*Salix* sp.)
- Forage: bog blueberry leaf (*Vaccinium uliginosum*), Labrador tea (*Ledum groenlandicus*) and Indian rhubarb leaf/yarrow (*Achillea millefolium*)
- Moss & lichen: moss (*Sphagnum* sp.), caribou lichen (*Cladina mitis*) and snow lichen (*Stereocaulon tomentosum*)

In addition, data are available for fungus (puffball mushroom [*Bovista plumbea*]), and for inner bark and/or sap from black spruce (*Picea mariana*), balsam fir (*Abies lasiocarpa*), and white spruce (*Picea glauca*). Samples have been collected from the Elsa tailings area, the Mackeno tailings area (around Christal Lake) and/or two 'control' areas (South McQuesten and Galena Hill). Additionally, the 2010 sampling program analyzed browse and forage samples from the No Cash, Silver King and Husky Shaft areas. A few samples have also been collected from Minto Bridge as it has been identified that FNNND collect medicinal plants from this area; however, it should be noted that this area is quite a distance from the historic Keno Hill Mine site. The summary statistics for all years are presented below on a dry weight basis for lichen and moss (Table 2.8), berries (Table 2.9), browse (Table 2.10), forage (Table 2.11), fungus (Table 2.12) and inner bark/sap (Table 2.13). Background averages were calculated from data collected in the South McQuesten and Galena Hill areas.

Table 2.8 Lichen and Moss Summary Statistics

Constituent	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Aluminum	79.2	73	0	97.6	735	28.7	119
Antimony	0.05	73	13	2.74	32.6	0.05	5.4
Arsenic	0.13	73	1	9.60	114	0.05	18.2
Barium	26.2	73	0	10.9	59.2	1.9	10.8
Beryllium	0.01	73	69	0.01	0.04	0.01	0.01
Boron	1.50	73	67	1.42	11	1.0	1.69
Cadmium	0.08	73	0	1.26	11.2	0.04	2.1
Calcium	2853	73	0	1763	14300	354	2220
Chromium	0.28	73	0	0.61	8	0.1	1.15
Cobalt	0.08	73	52	0.13	1.4	0.05	0.22
Copper	1.37	73	0	5.39	64.2	0.6	10.14
Iron	125	73	0	857	9840	48	1615
Lead	0.63	73	0	122	1800	0.4	277
Magnesium	709	73	0	469	2250	142	341
Manganese	135	73	0	270	2990	32.8	518
Mercury	0.01	73	64	0.02	0.15	0.005	0.02
Molybdenum	0.17	73	63	0.066	0.30	0.05	0.05
Nickel	0.50	73	0	0.70	7.5	0.20	1.15
Phosphorus	540	73	0	485	1410	261	192
Potassium	1755	73	0	1572	4410	809	677
Selenium	0.10	73	68	0.12	0.4	0.10	0.06
Silicon	170	73	0	146	513	63	92
Silver	0.03	73	0	1.92	17.0	0.02	3.37
Sodium	13.8	73	0	11.5	34.0	7	4.74
Strontium	6.0	73	0	3.85	22.7	1.04	4.04
Tellurium	0.05	73	73	0.05	0.05	0.05	0
Thallium	0.01	73	59	0.024	0.18	0.01	0.04
Tin	0.05	73	33	0.55	6.30	0.05	1.06
Titanium	3.75	73	0	3.6	20.0	1.7	2.76
Uranium	0.02	73	63	0.03	0.18	0.02	0.03
Vanadium	0.37	73	59	0.39	2.3	0.25	0.37
Zinc	19.2	73	0	89.2	907	8.8	144
Zirconium	1.5	73	73	1.50	1.50	1.5	0

Notes: Data from 2007 (lichen) and 2008 (lichen and moss)
'-' - No data available
Bkgd - Background locations considered to be undisturbed control areas (Galena Hill and South McQuesten)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

Table 2.9 Berries Summary Statistics

Constituent	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Aluminum	4.95	14	0	2.42	9.10	0.70	2.14
Antimony	0.05	14	12	0.12	1.00	0.05	0.25
Arsenic	0.05	14	6	0.39	3.20	0.05	0.82
Barium	10.8	14	0	8.51	34.5	1.90	7.74
Beryllium	0.01	14	14	0.016	0.05	0.01	0.015
Boron	6.00	14	1	13.4	33.0	1.0	8.14
Cadmium	0.29	14	1	0.24	0.55	0.01	0.18
Calcium	937	14	0	1321	4610	531	1010
Chromium	0.15	14	3	0.13	0.20	0.05	0.061
Cobalt	0.05	14	14	0.05	0.05	0.05	0
Copper	4.90	14	0	4.86	9.40	2.90	1.46
Iron	16.5	14	0	39.7	253	14.0	61.7
Lead	0.05	14	1	5.32	56.7	0.05	14.8
Magnesium	591	14	0	734	2260	295	464
Manganese	136	14	0	62.7	156	31.2	32.8
Mercury	0.005	14	14	0.005	0.005	0.005	0
Molybdenum	0.35	14	12	0.093	0.50	0.05	0.12
Nickel	1.00	14	2	0.48	1.90	0.05	0.47
Phosphorus	1185	14	0	883	1490	545	233
Potassium	8040	14	0	7416	12500	5820	1676
Selenium	0.10	14	14	0.10	0.10	0.10	0
Silicon	132	14	0	132	211	66.0	44.31
Silver	0.005	14	6	0.069	0.75	0.005	0.20
Sodium	3.50	14	2	5.64	24.0	0.50	7.19
Strontium	1.12	14	0	3.13	21.7	0.36	5.40
Thallium	0.01	14	14	0.01	0.01	0.01	0
Tin	0.05	14	11	0.068	0.20	0.05	0.042
Titanium	0.50	14	0	0.59	0.80	0.40	0.13
Uranium	0.02	14	14	0.02	0.02	0.02	0
Vanadium	0.25	14	14	0.25	0.25	0.25	0
Zinc	21.8	14	0	20.4	31.9	8.40	7.11
Zirconium	1.50	14	14	1.50	1.50	1.50	0

Notes: Data from 2008
'-' - No data available
Bkgd - Background locations considered to be undisturbed control areas (Galena Hill and South McQuesten)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

Table 2.10 Browse Summary Statistics

Constituent	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Aluminum	6.50	130	0	12.8	81.0	1.40	11.5
Antimony	0.05	131	85	0.25	3.10	0.05	0.56
Arsenic	0.051	131	21	0.86	10.3	0.005	1.89
Barium	53.6	131	0	15.0	200	0.50	22.8
Beryllium	0.01	131	113	0.036	0.05	0.01	0.019
Bismuth	5.48	81	64	0.05	0.05	0.05	$3.2x10^{-9}$
Boron	-	131	0	11.4	29.0	2.00	5.18
Cadmium	0.92	131	6	3.61	43.0	0.01	7.60
Calcium	5519	131	0	8642	20400	1930	4052
Chromium	0.092	131	82	0.40	8.00	0.05	0.81
Cobalt	0.25	131	72	0.22	8.10	0.05	0.77
Copper	1.42	131	0	5.07	31.1	0.60	3.53
Iron	21.7	131	0	101	854	6.00	148
Lead	0.089	131	10	7.53	125	0.05	18.4
Lithium	-	-	-	-	-	-	-
Magnesium	1575	131	0	1775	6800	453	1431
Manganese	319	131	0	168	1610	22.8	181
Mercury	0.005	131	112	0.0051	0.01	0.005	0.0006
Molybdenum	0.091	131	66	0.34	4.70	0.05	0.75
Nickel	0.99	131	5	1.99	42.8	0.050	4.68
Phosphorus	675	131	0	1006	3490	53.6	532
Potassium	1530	131	0	3540	12300	190	2154
Selenium	0.12	130	50	0.19	5.60	0.005	0.61
Silicon	30.6	50	0	69.2	172	13.0	53.5
Silver	0.0054	131	75	0.13	1.53	0.005	0.27
Sodium	4.06	131	59	6.00	45.0	0.50	6.19
Strontium	20.4	131	0	17.6	137	2.14	15.1
Sulphur	-	-	-	-	-	-	-
Tellurium	-	-	-	-	-	-	-
Thallium	0.011	131	100	0.025	0.16	0.01	0.022
Thorium	-	-	-	-	-	-	-
Tin	0.051	131	93	0.098	0.70	0.05	0.14
Titanium	0.48	131	79	0.61	3.00	0.15	0.47
Uranium	0.020	131	112	0.030	0.61	0.02	0.05
Vanadium	0.25	131	114	0.71	1.00	0.25	0.37
Zinc	89.9	131	0	294	1370	11.7	262
Zirconium	1.50	50	50	1.50	1.50	1.50	0

Notes: Data from 2008, 2009 and 2010
'-' - No data available
Bkgd - Background locations considered to be undisturbed control areas (Galena Hill and South McQuesten)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

Table 2.11 Forage Summary Statistics

Constituent	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Aluminum	6.41	74	0	18.1	210	1.60	28.4
Antimony	0.05	74	48	0.26	1.90	0.05	0.46
Arsenic	0.05	74	13	0.97	7.60	0.01	1.67
Barium	36.9	74	0	58.2	141	12.1	31.7
Beryllium	0.01	74	75	0.031	0.05	0.01	0.02
Bismuth	-	34	34	0.05	0.05	0.05	0
Boron	5.90	74	1	16.1	39.0	2.00	8.55
Cadmium	0.01	74	16	0.21	2.49	0.005	0.41
Calcium	2587	74	0	6309	11100	1890	2220
Chromium	0.08	74	38	0.36	3.30	0.05	0.48
Cobalt	0.05	74	71	0.06	0.30	0.05	0.03
Copper	1.49	74	0	4.11	7.90	0.70	1.66
Iron	12.8	74	0	100	768	7.00	134
Lead	0.07	74	6	9.44	88.6	0.05	19.7
Magnesium	625	74	0	1394	4050	391	718
Manganese	279	74	0	332	1160	24.3	282
Mercury	0.005	74	69	0.006	0.02	0.005	0.003
Molybdenum	0.05	74	71	0.06	0.40	0.05	0.04
Nickel	0.19	74	8	0.56	4.20	0.05	0.69
Phosphorus	592	74	0	923	3080	260	371
Potassium	1811	74	0	3380	8720	794	1453
Selenium	0.10	74	52	0.08	0.60	0.005	0.08
Silicon	34.8	40	0	98.7	210	18.0	59.9
Silver	0.005	74	44	0.14	1.20	0.005	0.27
Sodium	0.69	74	44	4.36	58.0	0.50	6.93
Strontium	4.38	74	0	9.27	17.8	1.87	4.36
Thallium	0.02	74	42	0.19	8.72	0.01	1.02
Tin	0.05	74	62	0.08	0.60	0.05	0.10
Titanium	0.30	74	38	0.70	6.00	0.15	0.72
Uranium	0.02	74	75	0.02	0.025	0.02	0.0025
Vanadium	0.25	74	75	0.59	1.00	0.25	0.38
Zinc	11.4	74	0	41.5	143	5.10	26.3
Zirconium	1.50	40	41	1.50	1.50	1.50	0

Notes: Data from 2008, 2009 and 2010
'-' - No data available
Bkgd - Background locations considered to be undisturbed control areas (Galena Hill and South McQuesten)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

Table 2.12 Fungus Summary Statistics

Constituent	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Aluminum	-	1	0	22.3	22.3	22.3	-
Antimony	-	1	0	0.20	0.20	0.20	-
Arsenic	-	1	0	17.0	17.0	17.0	-
Barium	-	1	0	1.10	1.10	1.10	-
Beryllium	-	1	1	0.01	0.01	0.01	-
Boron	-	1	1	1.0	1.0	1.0	-
Cadmium	-	1	0	5.31	5.31	5.31	-
Calcium	-	1	0	337	337	337	-
Chromium	-	1	0	0.10	0.10	0.10	-
Cobalt	-	1	1	0.05	0.05	0.05	-
Copper	-	1	0	284	284	284	-
Iron	-	1	0	123	123	123	-
Lead	-	1	0	44.8	44.8	44.8	-
Magnesium	-	1	0	1530	1530	1530	-
Manganese	-	1	0	46.4	46.4	46.4	-
Mercury	-	1	0	0.050	0.050	0.050	-
Molybdenum	-	1	0	0.20	0.20	0.20	-
Nickel	-	1	0	0.30	0.30	0.30	-
Phosphorus	-	1	0	8980	8980	8980	-
Potassium	-	1	0	27200	27200	27200	-
Selenium	-	1	0	1.50	1.50	1.50	-
Silicon	-	1	0	146	146	146	-
Silver	-	1	0	290	290	290	-
Sodium	-	1	0	6.0	6.0	6.0	-
Strontium	-	1	0	0.67	0.67	0.67	-
Thallium	-	1	0	0.02	0.02	0.02	-
Tin	-	1	1	0.05	0.05	0.05	-
Titanium	-	1	0	5.30	5.30	5.30	-
Uranium	-	1	1	0.02	0.02	0.02	-
Vanadium	-	1	1	0.25	0.25	0.25	-
Zinc	-	1	0	105	105	105.0	-
Zirconium	-	1	1	1.50	1.50	1.50	-

Notes: Data from 2008
'-' - No data available
Bkgd - Background locations considered to be undisturbed control areas (Galena Hill and South McQuesten)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

Table 2.13 Inner Bark/Sap Summary Statistics

Parameter	Bkgd. Average (mg/kg dw)	N	N<MDL	Average (mg/kg dw)	Maximum (mg/kg dw)	Minimum (mg/kg dw)	Std. Dev. (mg/kg dw)
Aluminum	4.55	7	0	18.5	56.8	1.40	18.5
Antimony	0.05	7	4	0.41	1.30	0.05	0.55
Arsenic	0.05	7	2	1.56	4.70	0.05	2.12
Barium	2.95	7	0	9.94	37.5	1.60	12.6
Beryllium	0.01	7	7	0.01	0.01	0.01	0
Boron	1.00	7	5	3.14	15.0	1.00	5.24
Cadmium	0.01	7	2	0.38	1.88	0.01	0.67
Calcium	259	7	0	1744	9930	67.0	3619
Chromium	0.30	7	0	0.26	0.40	0.10	0.10
Cobalt	0.05	7	6	0.07	0.20	0.05	0.06
Copper	0.08	7	0	1.46	3.10	0.30	1.23
Iron	5.25	7	0	148	358	12.0	148
Lead	0.05	7	0	19.3	52.5	0.20	24.0
Magnesium	9.05	7	0	95.6	489	10.3	175
Manganese	37.7	7	0	75.4	280	6.40	94
Mercury	0.005	7	7	0.005	0.005	0.005	0
Molybdenum	0.050	7	7	0.05	0.05	0.05	0
Nickel	0.05	7	5	0.11	0.30	0.05	0.10
Phosphorus	18.3	7	0	87.2	453	10.7	162
Potassium	42.5	7	0	272	1120	39.0	389
Selenium	0.10	7	7	0.10	0.10	0.10	0
Silicon	135	7	0	135	197	82.0	46.3
Silver	0.005	7	2	0.26	0.64	0.005	0.29
Sodium	2.00	7	0	3.71	12.0	1.00	4.07
Strontium	0.30	7	0	3.22	16.5	0.24	5.90
Thallium	0.015	7	4	0.024	0.08	0.01	0.026
Tin	0.050	7	5	0.14	0.40	0.05	0.15
Titanium	0.15	7	1	0.52	1.40	0.15	0.41
Uranium	0.02	7	7	0.02	0.02	0.02	0
Vanadium	0.75	7	3	0.56	0.90	0.25	0.30
Zinc	3.65	7	0	73.5	440	3.10	162
Zirconium	1.50	7	7	1.50	1.50	1.50	0

Notes: Data from 2008
'-' - No data available
Bkgd - Background locations considered to be undisturbed control areas (Galena Hill and South McQuesten)
MDL - Method detection limit; all values below the MDL were converted to ½ the MDL

2.3.2.3 Moose

Data were obtained from the FNNND (Tremblay, pers. comm. 2011) on concentrations of metals in the kidney and liver of two different moose obtained in the fall of 2009 and 2010, respectively, The kidney sample was obtained from a moose on Duncan Creek road in the Lightning Creek area, while the liver sample was obtained from a moose in the South McQuesten River area. The original data for the kidney was obtained on a wet weight basis, while that for the liver was on a dry weight basis; to provide a consistent basis, the dry weight values were converted to dry weight using the reported moisture content of 63.9%. Values below the MDL were converted to ½ the MDL. The results are presented in Table 2.14.

Table 2.14 Moose Kidney and Liver Data

Constituent	Concentration (mg/kg ww)	
	Kidney	Liver [a]
Aluminum	1 [b]	1.81 [b]
Antimony	0.005 [b]	0.009 [b]
Arsenic	0.005 [b]	0.05
Barium	0.42	0.22
Beryllium	0.05 [b]	0.054 [b]
Bismuth	0.015 [b]	0.054 [b]
Cadmium	17.3	8.6
Calcium	109	62.5
Chromium	0.15	0.09 [b]
Cobalt	0.053	0.26
Copper	2.38	71.5
Iron	32.5	62.1
Lead	0.023	0.018 [b]
Lithium	0.05 [b]	0.09 [b]
Magnesium	142	229
Manganese	0.849	2.07
Mercury	0.0076	0.014
Molybdenum	0.128	0.89
Nickel	0.05 [b]	0.09 [b]
Phosphorus	2040	3718
Potassium	1840	3058
Selenium	0.61	1.34
Sodium	2080	722
Strontium	0.16	0.061
Thallium	0.005 [b]	0.0054 [b]
Tin	0.025 [b]	0.036 [b]
Titanium	0.05 [b]	0.09 [b]
Uranium	0.001 [b]	0.0018 [b]
Vanadium	0.05 [b]	0.09 [b]
Zinc	25.2	24.9

Notes: Data from 2009 and 2010
MDL - Method detection limit
a - Values converted from a dry weight to wet weight basis using a reported moisture content of 63.9%
b - Value below the MDL; converted to ½ the MDL

2.4 SELECTION OF CONSTITUENTS OF POTENTIAL CONCERN

The approach to identify Constituents of Potential Concern (COPC) at the historic Keno Hill Mine site is similar to approaches used at the Anvil Mine Range and Mount Nansen in the Yukon and other mine sites in the Northwest Territories. A selection process was performed to identify COPC for the site, the results of which are presented below. Details are provided in Appendix A. The selection process was primarily related to the measured surface water and soil concentrations, although the measured sediment and terrestrial vegetation concentrations were used in a secondary screen to infill COPC that may not have been identified based on the surface water and soil screens. The selection process was limited to inorganic constituents (metals, ammonia, sulphate, nitrite and nitrate) since measured data on concentrations of organics (i.e., volatile organic compounds, polycyclic aromatic hydrocarbons, petroleum hydrocarbons) are not available.

2.4.1 Selection Process

Data on the concentrations of the constituents in surface water, sediment, soil and terrestrial vegetation were obtained from the various sampling programs discussed previously (Sections 2.2 and 1.1). The COPC were selected by comparing maximum measured concentrations in each medium to the applicable Canadian Council of Ministers of the Environment (CCME) guidelines, where available. In the absence of CCME guideline values, other guideline values were used where available.

The process that was applied to identify COPC is presented in Figure 2.5. In general, the COPC identification process involved four steps:

Step 1 – If more than 90% of measured concentrations of samples from an affected area were reported as below the MDL, then the data were considered to be heavily censored and were not considered further.

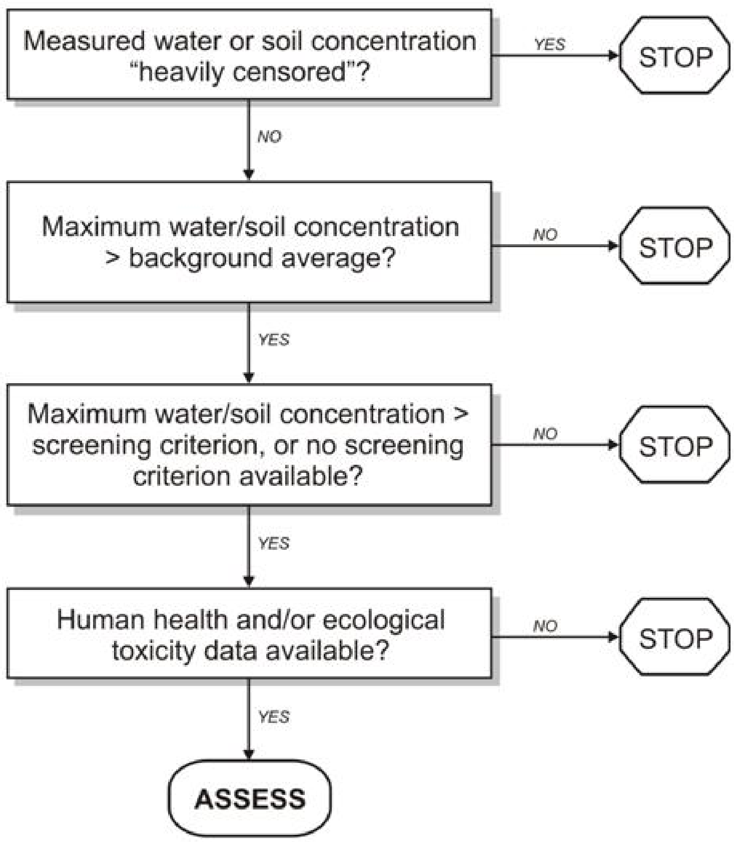
Step 2 – Maximum concentrations in the affected areas were compared to background concentrations obtained from reference sites in the study area. If the maximum concentration from an affected area was greater the background average, then the constituent was not considered to be a COPC.

Step 3 – Constituents identified to have higher concentrations in affected areas than those at reference sites (i.e., from Step 2) were then compared to the appropriate screening criteria (e.g., CCME guideline value). Constituents with concentrations lower than the screening criteria were dropped from further assessment, while those with maximum concentrations exceeding the screening criteria, or with no criteria available, were carried forward to Step 4.

Step 4 – Constituents identified in Step 3 were checked to see if corresponding human health and/or ecological toxicity data are available. Constituents with available toxicity data were selected as COPC, while those without toxicity data were not further assessed. Although this adds some uncertainty to the assessment, the lack of toxicity data generally denotes constituents that are not considered to be toxic. Therefore, the final COPC list captures the constituents of major concern at the historic Keno Hill Mine site.

The above process was used to identify COPC in soil and surface water. A similar procedure was used to infill COPC based on sediment and terrestrial vegetation concentrations; however, the procedure differed in that if no screening criterion was available for a constituent, then that constituent was automatically not considered further.

Figure 2.5 Selection Process for Constituents of Potential Concern



Notes:
"heavily censored" – > 90% of measurements used to calculate the mean were below the MDL

2.4.2 Surface Water Screening

The CCME Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME 2011) were used when available for the selection of COPC in surface water. In the absence of aquatic life values, guidelines for Canadian Drinking Water Quality (Health Canada 2010) were used as the selection criteria.

For the selection of COPC in surface water, the maximum measured concentrations of the constituents from impacted surface water samples were compared to the screening criteria, taking the site maximum to be the value of concern. Source water bodies (i.e., adits, tailings/treatment pond) samples were not considered representative of the site conditions as a whole and therefore measurements from these samples were not included in the COPC selection process. Additionally, human and ecological receptors are unlikely to have major pathways of exposure associated with these areas. Background concentrations were calculated from data from several reference locations.

Aluminum was present at a maximum concentration exceeding the applicable criterion; however, as discussed in detail in Appendix A, the pH in the aquatic environment at the United Keno Hill site is between pH 5.5 and 9 (average of 7.7) and in this range there is very little aluminum that is in true solution and available for uptake by biological species (Gardner *et al*. 2002). Aluminum was therefore not selected as a COPC.

The COPC identified through the screening of available surface water data for the site include antimony, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, uranium, vanadium and zinc.

2.4.3 Sediment Screening

Maximum concentrations of the constituents in sediment from impacted water bodies were compared to the CCME Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME 2011). In the absence of a value from the CCME, sediment criterion values developed by Thompson *et al.* (2005) were used. The sediment toxicity benchmarks from Thompson *et al*. (2005) were developed for mining industry applications in northern Saskatchewan. The benchmark values reported by these authors cover a much wider range than those proposed by the CCME.

As the purpose of the sediment screen was to identify COPC that may not have been identified in the surface water screening process, if no sediment criteria were available from either source, the constituent was dropped from further consideration.

The constituents that satisfied all the conditions of the sediment screening process for the site were arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, uranium, vanadium and zinc, all of which were previously identified as COPC in the surface water screening process. No further COPC were added to the list from the sediment screening process.

2.4.4 Soil Screening

For the selection of COPC in soil, the maximum measured concentrations of constituents in soil from impacted water bodies were compared to the CCME Soil Quality Guidelines for the Protection of Environmental and Human Health developed for residential/parkland use (CCME 2011). The use of the most restrictive residential/parkland criteria ensures that all potential COPC are captured in the screening process. Samples obtained directly from the Elsa tailings were not included in the data set used to select the COPC as tailings are not considered to be soil.

The COPC identified through the screening of available soil data for the site were antimony, arsenic, barium, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, strontium, thallium, zinc and zirconium. Toxicity data for zirconium are only available for terrestrial wildlife receptors and not humans and therefore zirconium will only be evaluated as a COPC for the terrestrial assessment.

2.4.5 Terrestrial Vegetation Screening

Maximum concentrations of the constituents in all terrestrial vegetation (forage, browse, lichen, berries, etc.) from impacted areas were compared to phytotoxicity values reported by McBride (1994), Langmuir *et al.* (2004) or Davis *et al.* (1978).

As the purpose of the terrestrial vegetation screen was to identify COPC that may not have been identified in the soil screening process, if no phytotoxic values were available for a constituent than that constituent was dropped from further consideration.

The constituents that satisfied all the conditions of the terrestrial vegetation screening process for the historic Keno Hill Mine site were arsenic, cadmium, chromium, cobalt, lead, selenium and zinc. With the exception of chromium, all of these COPC were previously identified in the soil screening process. Chromium was therefore added to the list of COPC.

2.4.6 COPC Summary

In summary, surface water and soil samples were used to identify the main list of COPC while sediment and terrestrial vegetation samples were used to infill the list as necessary. The COPC selected are provided in Table 2.15. Further details on the selection process are provided in Appendix A.

Table 2.15 Summary Table of COPC Selected for the Historic Keno Hill Mine Site

Constituent	COPC?		
	Aquatic Assessment	Terrestrial Assessment	Human Health Assessment
Ammonia - N			
Aluminum			
Antimony	Y (1)	Y	Y
Arsenic	Y	Y	Y
Barium		Y	Y
Beryllium			
Bismuth			
Boron			
Cadmium	Y	Y	Y
Calcium			
Chromium	Y	Y	Y
Cobalt	Y (1)	Y	Y
Copper	Y	Y	Y
Iron	Y (1)		
Lead	Y	Y	Y
Lithium			
Magnesium			
Manganese	Y (1)	Y	Y
Mercury	Y	Y	Y
Molybdenum	Y	Y	Y
Nickel	Y	Y	Y
Phosphorus			
Potassium			
Selenium	Y	Y	Y
Silicon			
Silver	Y (1)	Y	Y
Sodium			
Strontium	Y (1)	Y	Y
Sulphur			
Tellurium			
Thallium		Y	Y
Thorium			
Tin			
Titanium			
Uranium	Y	Y	Y
Vanadium	Y	Y	Y
Zinc	Y	Y	Y
Zirconium		Y	N (2)

Notes:
1 - No sediment toxicity data are available
2 - Although the maximum concentration is above the guideline value, no human health toxicity data are available

3.0 RECEPTOR CHARACTERIZATION

One of the key considerations, which defines the scope of a risk assessment, is the selection of ecological and human receptors and identification of their pathways of exposure to the COPC. In selecting receptors it is important to identify plants, animals and people that are likely to be most exposed to COPC at the historic Keno Hill Mine site as well as those that may be important for other ecological or social reasons. This section details the ecological (aquatic and terrestrial) and human receptors that will be selected for the assessment and the rationale behind their selection.

3.1 ECOLOGICAL RECEPTORS

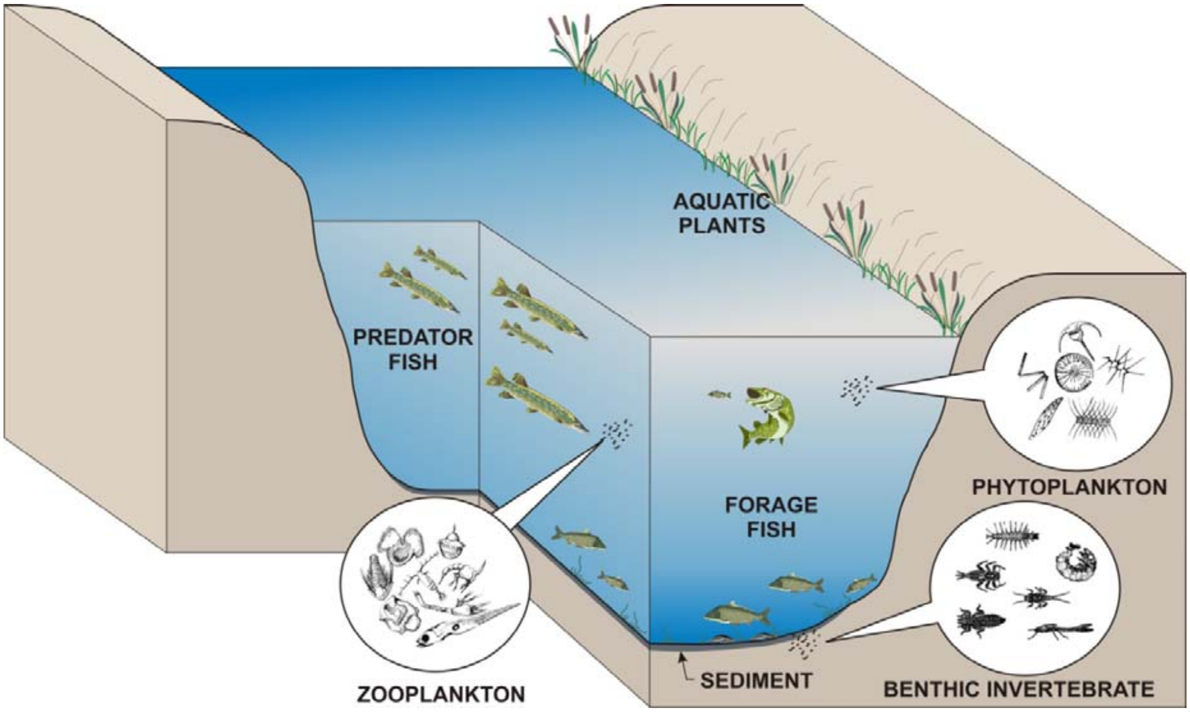
The first step in an ecological risk assessment is the determination of which ecological species should be examined. It is not practical or necessary to evaluate risks to all ecological species; it is common practice to select representative species based on level of potential exposure, importance as a food source for other species and/or humans, importance for cultural reasons, or because they are endangered or rare species. Therefore, ecological receptors are generally chosen to capture various levels of exposure via their different behavioural and dietary characteristics. They are also selected if they are considered important: (1) in the functioning of the ecosystem; (2) in the production of food for subsistence; or (3) due to their cultural, legal or medicinal significance.

In this assessment, exposure is primarily from aquatic pathways; thus, several ecological receptors were selected to capture exposure from drinking water and consumption of aquatic plants, fish, invertebrates and sediments. Secondary exposure pathways also affected by the historic Keno Hill Mine site were similarly included, and thus selected wildlife species that receive most of their exposure via atmospheric and terrestrial pathways were also considered.

3.1.1 Aquatic Receptors

The aquatic species chosen for this assessment cover all food chain (trophic) levels that would be expected to be found in the lake systems in the vicinity of the study area (e.g., Christal Creek, Flat Creek, Lightning Creek, South McQuesten River, etc.). Figure 3.1 provides a schematic representation of the selected ecological receptors for the aquatic environment.

Figure 3.1 Aquatic Receptors Included in the Assessment



Primary Producers - Primary producers occupy the lowest level in the food chain. These organisms are generally plants that use the sun and inorganic molecules to produce food.

Aquatic plants in most lake ecosystems usually constitute the majority of the primary producer biomass. Aquatic plants are often consumed by moose, muskrat and other animals, thereby forming a link between aquatic and terrestrial ecosystems. Besides being an important food resource, aquatic plants also provide habitat to aquatic organisms.

Phytoplankton are also part of the first level in the aquatic food chain. Members of the division *Chlorophyta* have been studied extensively and are relatively common in most northern aquatic ecosystems. Even though the overall contribution of *Chlorophyta* to northern aquatic ecosystems is relatively small, they are a primary food resource for grazing zooplankton.

Primary Consumers - Primary consumers occupy the second level in the food chain. These organisms generally eat plant material such as phytoplankton.

Zooplankton such as *Cladocerans* are found in most northern aquatic ecosystems. Although *Cladocerans* may be seasonally quite abundant, their overall contribution to northern aquatic ecosystems is relatively small.

Benthic invertebrates both live and feed within sediments and provide a link between aquatic and terrestrial ecosystems. For example, *Chironomidae* (midge) larvae are usually the most abundant benthic invertebrate taxa present in aquatic ecosystems in the northern climate. Many species feed on decaying organic matter and thereby form an important link between the decomposer and primary consumer levels. Furthermore, midge larvae are a main food source for small/juvenile fish and larger omnivorous fish. The adults are capable of flight and are frequently consumed by birds and bats. This life stage provides an important link between aquatic and terrestrial ecosystems in the region.

Secondary Consumers - Ecological receptors at the secondary consumer level include forage fish that feed primarily on benthic invertebrates and smaller individuals, and are an important food source for larger predatory fishes. Examples of forage fish are Arctic grayling and slimy sculpin, which are prevalent in the study area water bodies (Minnow 2009).

Tertiary Consumers - Tertiary consumers are found at the top end of the aquatic food chain and consist of larger predatory fish species that consume other fish species. Although forage fish are more common in the area than predator fish, lake trout, northern pike and lake whitefish have been documented in Christal Creek and Flat Creek in the past, and more recently juvenile northern pike have been captured in Flat Creek. Additionally, predator fish are found in surrounding water bodies such as Mayo and Wareham lakes. The Chinook salmon, although found in rivers in the study area, is in relatively low abundance (Minnow 2009). Predatory fish are also an important component of the human food chain. Both forage and predatory fish are an important component of the diet of omnivores and carnivores.

3.1.2 Terrestrial Receptors

The terrestrial receptors that will be chosen for this assessment are presented in Table 3.1 The receptors were selected based on information presented in various environmental assessment reports (Laberge 2005, 2008; Minnow 2009; WMEC 2006), as well as information on species common to the area from Hinterland Who's Who database maintained by Environment Canada & Canadian Wildlife Federation (EC/CWF 2011). The risk assessment cannot evaluate all the ecological species found in the area; rather, the risk assessment evaluates species that cover a wide range of dietary habits that can act as surrogates for other species.

Table 3.1 Terrestrial Receptors for the Historic Keno Hill Mine Site

Herbivores	Omnivores	Carnivores
- Beaver - Grouse - Snowshoe hare - Hoary marmot - Moose - Dall sheep - Woodland caribou	- Black bear - Waterfowl (mallard, scaup, merganser) - Red fox - Grizzly bear	- Mink - Wolf

The receptors were selected to represent a wide range of exposures and are discussed below.

Herbivores - Herbivores convert vegetable matter to animal protein, and in turn are consumed by omnivores and carnivores. They are also trapped or hunted for fur and food. Beaver, caribou, grouse, hare, marmot, moose and sheep are the herbivores selected for this assessment.

Beaver – The beaver habitat is largely in the aquatic environment, although terrestrial vegetation (browse) comprises a significant part of their diet. Beaver were included in this assessment because they have been identified as being consumed by the First Nation of Na-Cho Nyäk Dun (FNNND) people and because they are an indicator of both potential aquatic and terrestrial effects.

Caribou – Caribou consume predominantly lichen, which are mostly impacted by chemical deposition from the air. Caribou were chosen since they are known to be in the general area and represent a portion of the diet of the FNNND.

Grouse – Grouse (and ptarmigan) are terrestrial birds common in the northern environment. The diets of both species are primarily terrestrial, comprising primarily berries and browse. Grouse was selected to represent both species.

Snowshoe Hare – The snowshoe hare was chosen as it may be trapped in the area and used as a food source. Browse and forage comprise most of the diet of hare.

Hoary Marmot – The hoary marmot feeds on grass and other green plants (forage). Hoary marmots are protected from being hunted in the Yukon, except by FNNND.

Moose – Moose consume aquatic macrophytes and browse and thus are potentially an exposed species. Moose may be exposed to COPC via terrestrial pathways and given that moose are an important source of food to people in the study area, they will be included in the assessment.

Dall Sheep – There are 19,000 to 23,000 Dall Sheep in the Yukon. Dall Sheep have been reported in the Keno Hill area. They are also a protected species but are hunted by FNNND. Their diet consists of terrestrial vegetation (forage).

Omnivores - Omnivores consume both plant and animal matter. Vertebrate omnivores included are bear, red fox and waterfowl.

Bear – A bear’s diet is composed of terrestrial vegetation (forage), berries, fish and carrion (moose and caribou); therefore, the bear is an important indicator of potential effects of atmospheric deposition and constituent transfer from air and soil (terrestrial vegetation and berries), and effects on the aquatic environment (fish). Grizzly bears and black bears have similar diets and were thus evaluated as one receptor (‘bear’).

Red Fox - Foxes are predatory species and thus are exposed via food chain effects. They are omnivores and consume a varied diet including berries, ducks and hare.

Waterfowl (i.e., mallard, merganser, scaup) – Waterfowl are often the most exposed ecological receptors since their diet is almost entirely obtained from the aquatic environment. The waterfowl diet includes aquatic vegetation, fish, and aquatic (benthic) invertebrates. The different duck species are representative of other waterfowl that are present in the area. The three species were selected to take into account differences in the diets of mallard (consumes aquatic plants and benthic invertebrates), merganser (consumes mainly fish) and scaup (consumes mainly benthic invertebrates). Ducks are also part of the human food chain.

Carnivores - Predators represent the top level of the food chain. Predators interact with prey species (usually herbivores) and may influence population levels and distribution of prey. Terrestrial predators to be included in the assessment include the mink and wolf.

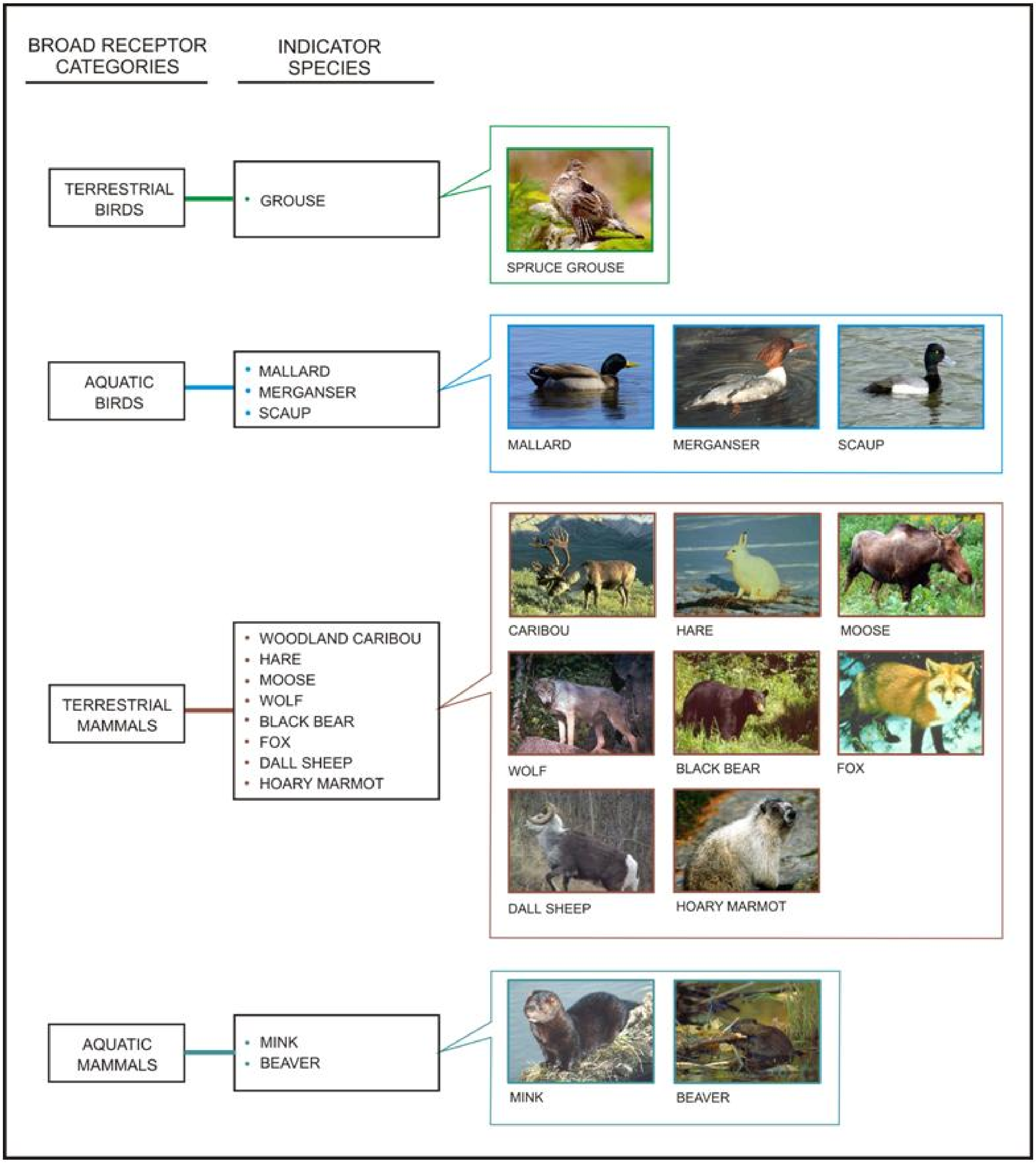
Mink – Mink are found in the Yukon and consume aquatic plants, benthic invertebrates, fish, ducks and small mammals and are thus potentially exposed via both the aquatic and terrestrial pathways.

Wolf - The wolf is a predatory species that consumes a number of other species including caribou, hare and moose. Food chain effects are assessed in this study through the inclusion of the wolf.

All of the terrestrial species mentioned above were assumed to consume soil or sediment, depending on where they obtained their food from, in addition to the food sources noted above.

Figure 3.2 provides a schematic of the receptors that will likely be selected for this assessment. Section 3.1.3 discusses the pathways that will be considered in the assessment.

Figure 3.2 Terrestrial Receptors Considered for the Assessment



3.1.3 Ecological Pathways

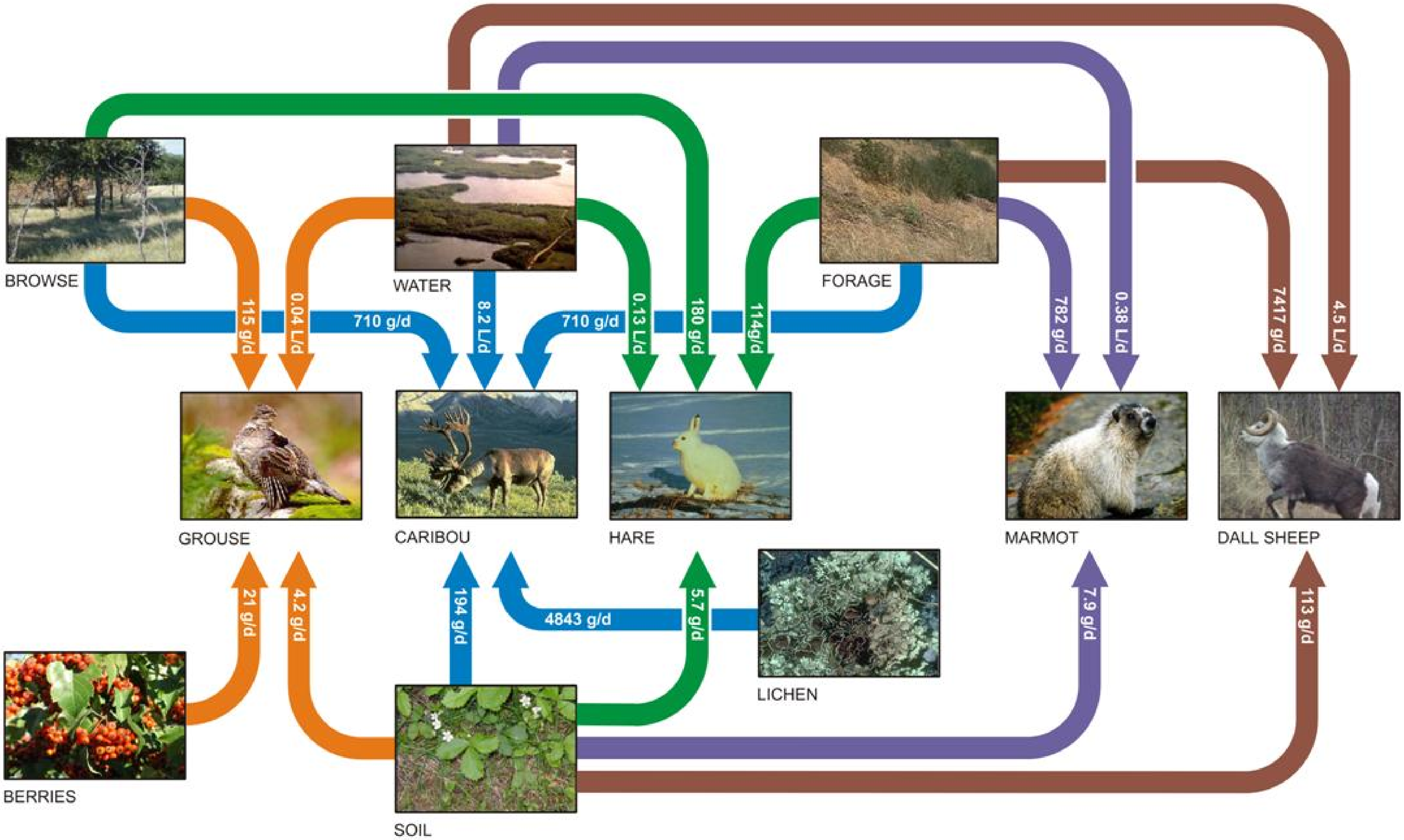
Ecological receptor characteristics were chosen to represent a reasonable maximum exposure scenario, in that cautious assumptions were made regarding the receptor's behaviour and home range. Ecological receptors were assumed to spend considerable amounts of time in the affected areas, when in reality it is unlikely that wildlife would spend much time in those areas due to the lack of suitable habitat or sufficient food.

Several different pathways were considered in the ecological assessment. These pathways are linked to either the aquatic environments that may be affected by the site (e.g., Lighting Creek, Christal Creek, Flat Creek, South McQuesten River, etc.) and/or the terrestrial environment including the historic Keno Hill Mine site and surrounding areas.

Figure 3.3 through to Figure 3.6 provide schematic representations of the potential pathways of exposure for each terrestrial receptor that was selected for the assessment. The figures also provide the typical intake rates that were used for all the pathways considered for each of the terrestrial receptors. In this assessment, terrestrial species were either located primarily in the aquatic environment (i.e., beaver, waterfowl, mink) or primarily in the terrestrial environment (i.e., bear, caribou, fox, hare, marmot, moose, grouse, sheep, wolf). Exposure to COPC is primarily from aquatic pathways; thus, the receptors were selected to capture exposure from drinking water and consumption of aquatic plants, fish, invertebrates and sediments.

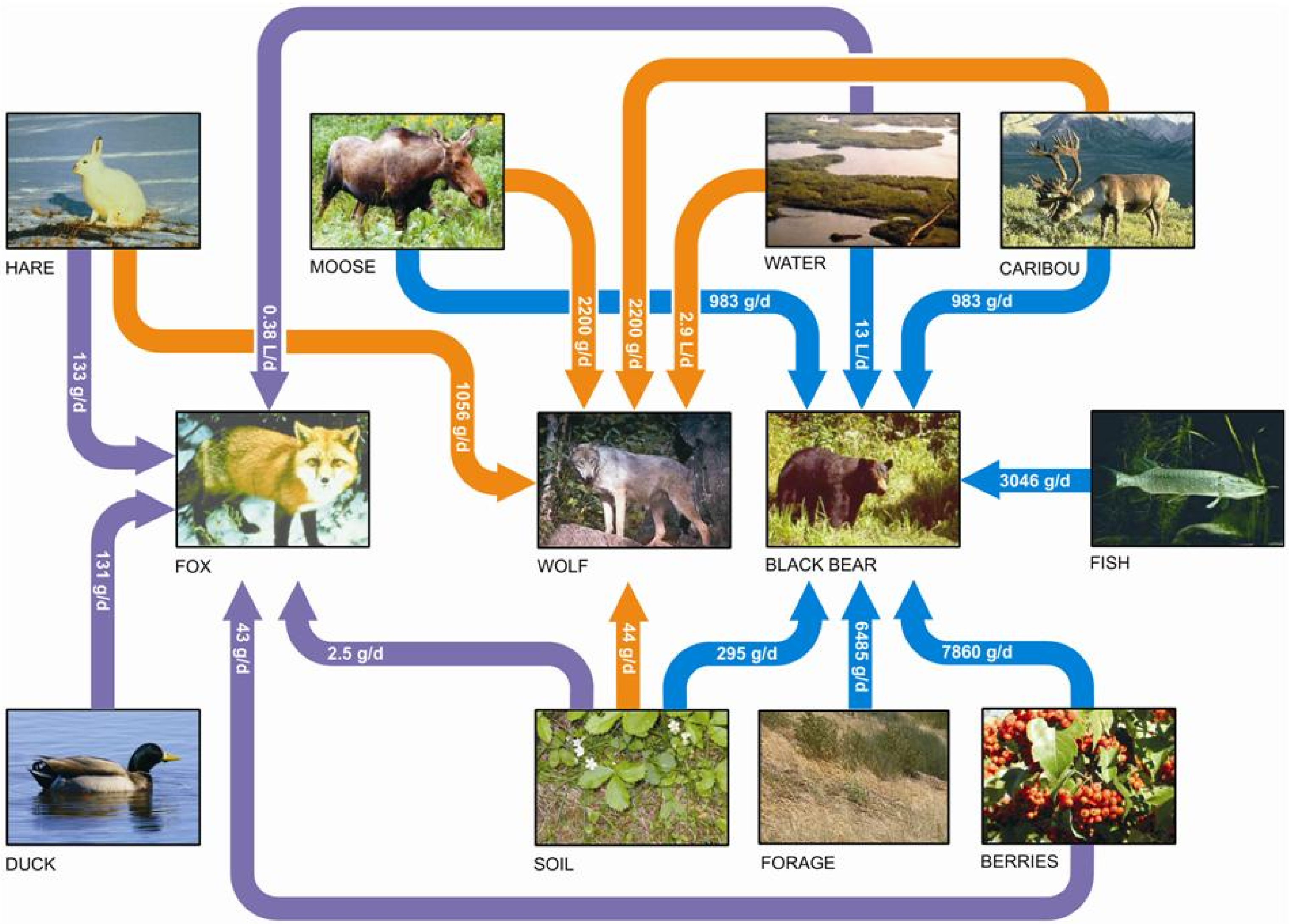
In addition to considering the dietary characteristics of each receptor, it is important to consider the area(s) from where the receptors obtain their food and what the COPC levels are in the food items in the(se) area(s). In this regard, the home range of each of the species was also taken into consideration when linking the species to food sources. Table 3.2 summarizes the home range of the receptors and the proposed fraction of time that is assumed to be spent on-site.

Figure 3.3 Potential Pathways of Exposure for Caribou, Grouse, Hare, Marmot and Sheep



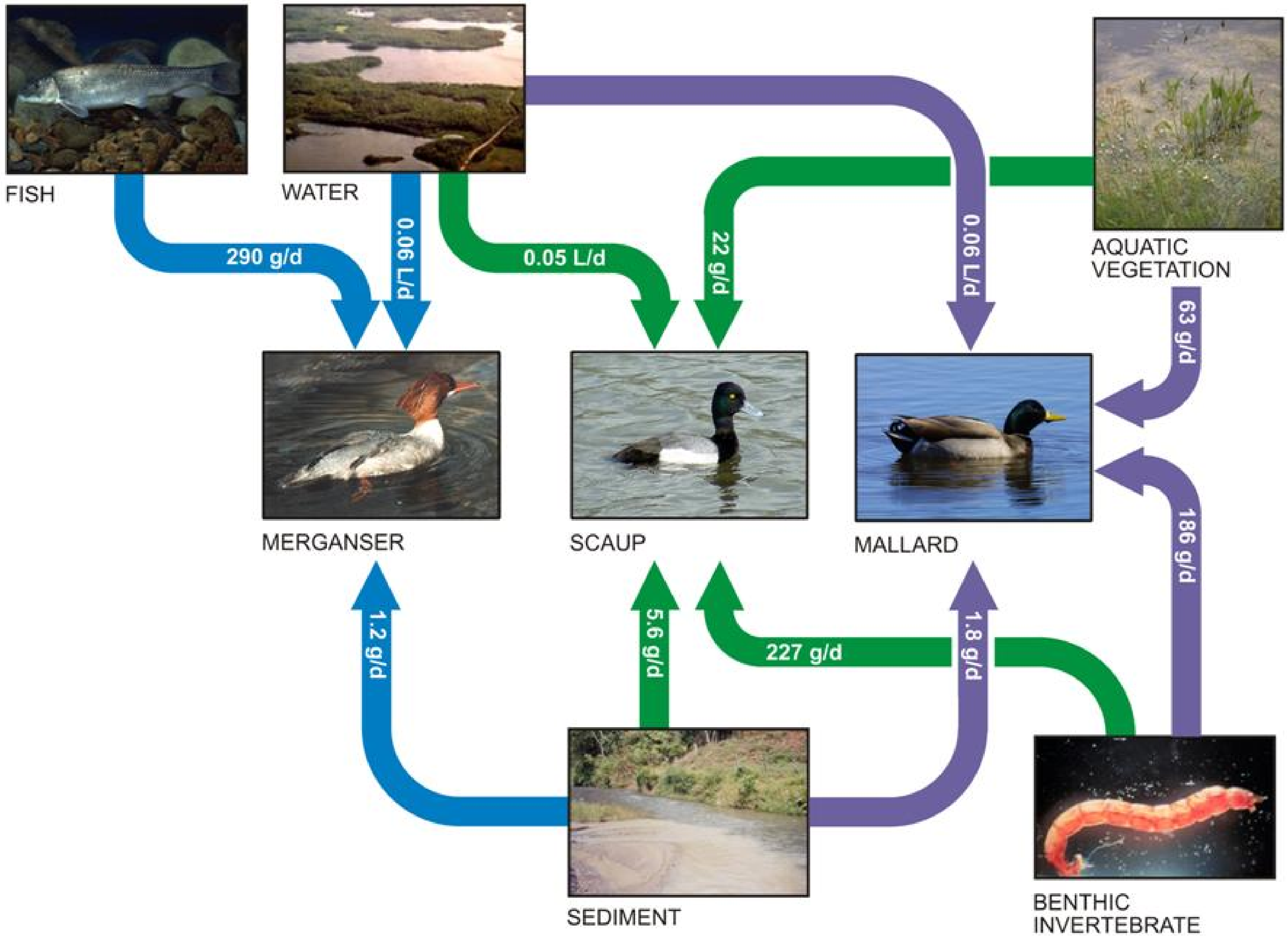
Notes: All intakes are on a wet weight basis except for soil and sediment which is on a dry weight basis.

Figure 3.4 Potential Pathways of Exposure for Black Bear, Fox and Wolf



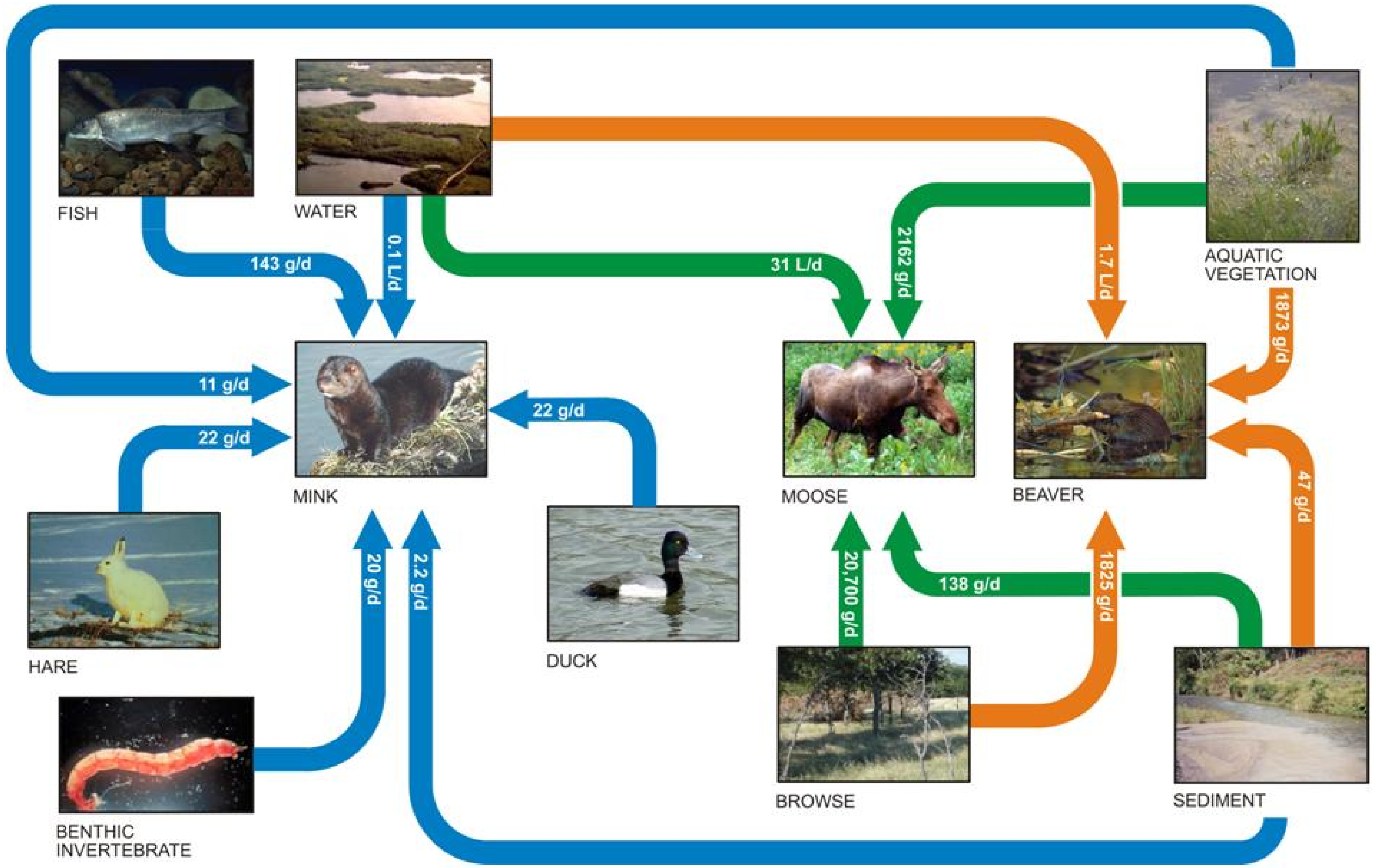
Notes: All intakes are on a wet weight basis except for soil and sediment which is on a dry weight basis.

Figure 3.5 Potential Pathways of Exposure for Mallard, Merganser And Scaup



Notes: All intakes are on a wet weight basis except for soil and sediment which is on a dry weight basis.

Figure 3.6 Potential Pathways of Exposure for Mink, Moose And Beaver



Notes: All intakes are on a wet weight basis except for soil and sediment which is on a dry weight basis.

Table 3.2 Exposure Characteristics Assumed for Terrestrial Ecological Receptors

Receptor	Pathways of Exposure	Fraction of time at site	Home Range
Bear	Water, soil, herbaceous vegetation, berries, fish, moose, caribou	1.0	20 km^2 (2.6 to 155 km^2) [a]
Beaver	Water, sediment, terrestrial vegetation, aquatic vegetation	1.0	0.04 km^2 (varies throughout the year from 0.25 ha to 10 ha; focussed on water's edge) [b]
Caribou	Water, soil, summer forage, browse, lichen	0.5	250 km^2 [c]
Fox	Water, soil, berries, duck, hare	1.0	6 km^2 (4 to 8 km^2 around den site) [d]
Grouse	Water, soil, browse, berries	1.0	0.2 km^2 (no migration - resident year round; 0.04 to 0.40 km^2) [e]
Hare	Water, soil, browse, herbaceous vegetation	1.0	0.08 km^2 (6 to 10 ha) [d]
Hoary Marmot	Water, soil, herbaceous vegetation	1.0	0.09 km^2
Mallard	Water, sediment, benthic invertebrates, aquatic vegetation	0.5	5.8 km^2 [f] (home range in spring - possibly in area from Mar /Apr/May to Sept/Oct/Nov)
Merganser	Water, sediment, fish	0.5	Possibly in area from April to Sept/Oct
Mink	Water, sediment, aquatic vegetation, benthic invertebrates, duck, fish, hare	1.0	0.14 km^2 [f] (7.8 to 20.4 ha depending on vegetation)
Moose	Water, sediment, browse, aquatic vegetation	1.0	60 km^2 [g] (15 to 100 km^2)
Scaup	Water, sediment, benthic invertebrates, aquatic vegetation	0.5	0.89 km^2 [f] (possibly in area from Apr/May to Sept/Oct)
Sheep	Water, soil, herbaceous vegetation	1.0	Resident in the area year-round
Wolf	Water, soil, moose, caribou, hare	0.25	1000 km^2 (100 to 2500 km^2) [h]

Notes:

a Home range for a female bear can range between 2.6 km^2 to 40 km^2; the home range for a male bear can range from 21 km^2 to 155 km^2 (American Bear Association 2003).

b Wheatley 1994; Kent Wildlife Trust (2003).

c Rock (1992).

d Hinterland Who's Who (Environment Canada & Canadian Wildlife Federation (EC/CWF) 2011).

e Home range for a female grouse is from 0.16 km^2 to 0.40 km^2; home range for a male grouse is from 0.04 km^2 to 0.20 km^2 (North Carolina State University 1995).

f U.S. EPA (1993).

g In northern Saskatchewan, it is reported that moose may range over 25 to 100 km^2 (Cameco 2004). Home range studies based on radio-collared individuals were reported to average 59 km^2 for the Copper River Delta in south-central Alaska (MacCracken *et al.* 1997). In more southerly regions such as Idaho, the home range for female moose has been observed to range from 15.5 to 25.9 km^2, and for male from 31 to 51.8 km^2 (Pierce and Peck 1984).

h In Alaska, the home range may include some 200 to 600 square miles (520-1560 km^2) of habitat (Woodland 2005). Home range is 100 to 2500 km^2 (Resources Inventory Committee 1998).

3.2 HUMAN RECEPTORS

The following section outlines the assessment of potential incremental exposures to humans that may utilize the Keno Hill area. For the purposes of this assessment, assumed human characteristics were defined to calculate potential exposures under current site conditions. This assessment considers the potential for adverse effects on hypothetical individuals who may camp in the area while hunting and gathering as outlined in the workplan for the risk assessment. It was assumed that the time that a hypothetical camper might spend on-site would encompass the time frame that trappers and other occasional users might be on the site. Thre are a few (6 to 8) year-round residents in the area whose exposures may be captured in this assessment. Year-round residents will be considered at a subsequent phase.

3.2.1 Selection of Appropriate Receptors

It was assumed that a hypothetical family may camp in the area while carrying out their hunting and gathering activities; therefore, an adult, child and toddler were considered in the assessment. It was assumed that an infant would not be brought onto the site for these activities and was therefore not included in the assessment.

The exposure to humans from COPC at the site depends on behavioural characteristics, such as time at the site and source of drinking water and food. Conservative assumptions were made in the characterization of human receptors for this assessment. It was assumed that campers would be present at the site for approximately 1.5 months of the year, and would be present largely in the South McQuesten area where Flat Creek empties into the South McQuesten River and the Galena Hill area around Lightning Creek. Food hunted and gathered while on site will be taken back to the community and consumed over a 6 month period.

3.2.2 Pathways of Exposure

The human exposure analysis focused on the pathways as shown in Figure 3.7. They include:

- consumption of drinking water containing COPC from water bodies such as Lighting Creek, Christal Creek, Flat Creek, and the South McQuesten River;
- uptake by caribou of COPC from water, soil and vegetation and subsequent consumption of caribou flesh by humans;
- uptake by moose of COPC from water, sediment and aquatic and terrestrial vegetation and subsequent consumption of moose flesh by humans;
- uptake by sheep of COPC from water, soil and vegetation and subsequent consumption of sheep flesh by the human receptors;
- uptake by snowshoe hare of COPC from water, soil and vegetation and subsequent consumption of hare flesh by the human receptors;

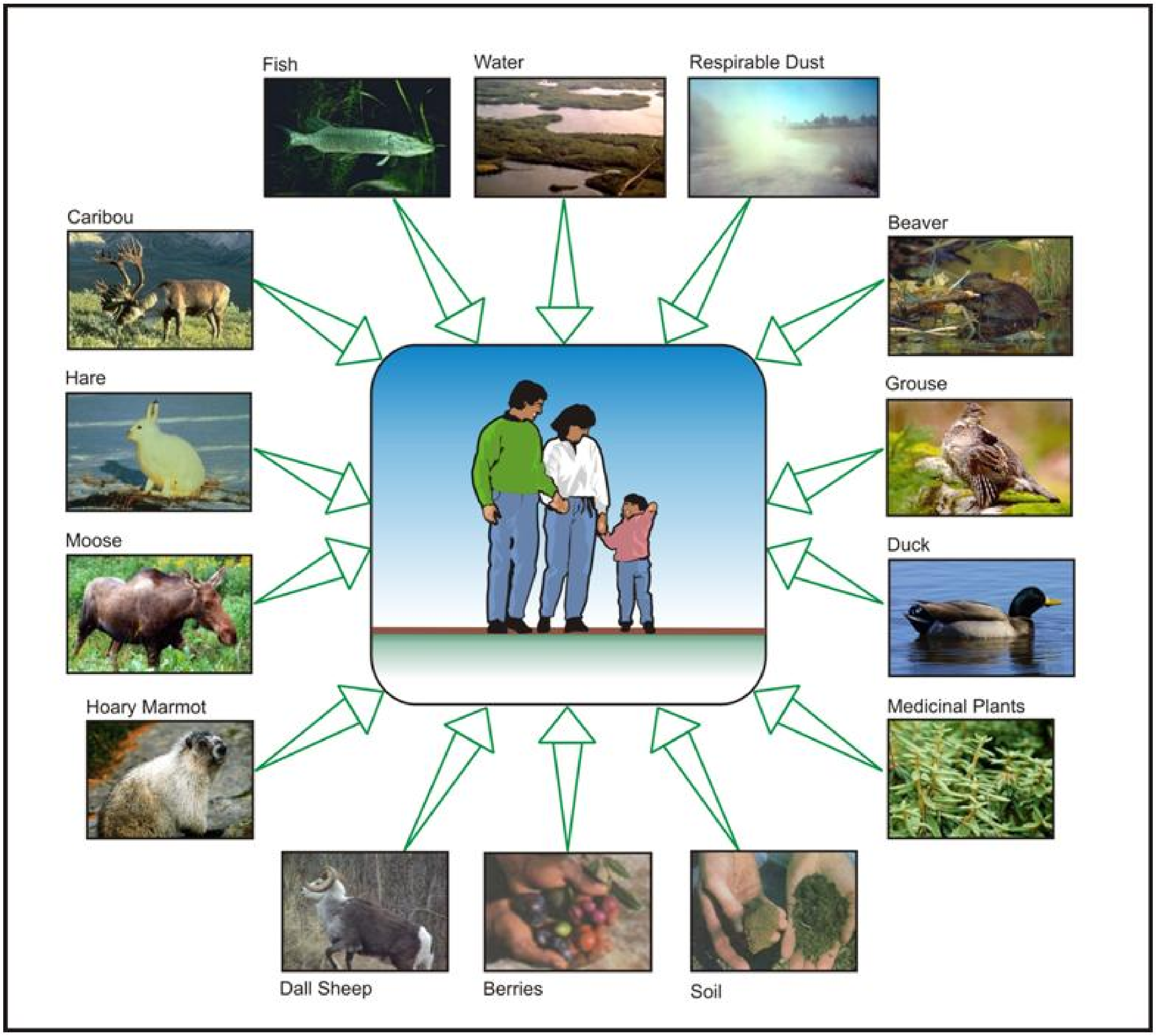
- uptake by hoary marmot of COPC from water, soil and vegetation and subsequent consumption of marmot flesh by the human receptors;
- uptake by grouse of COPC from water, soil and vegetation and subsequent consumption of grouse flesh by humans;
- uptake by beaver of COPC in water, sediments and vegetation and subsequent consumption of beaver flesh by humans;
- uptake by waterfowl of COPC in water, sediment, benthic invertebrates and/or aquatic vegetation and subsequent consumption of waterfowl flesh by humans;
- uptake by fish of COPC from the aquatic environment (e.g., Lighting Creek, Christal Creek, Flat Creek, South McQuesten River, etc.) and subsequent consumption of fish flesh by humans;
- uptake of COPC in soil by berries and/or medicinal plants and subsequent consumption of berries and/or medicinal plants by humans; and,
- inadvertent ingestion of and dermal contact with soil containing COPC.

Although there are domestic wells in Keno City, they are not suspected of being used for drinking water. Additionally, the main well at the firehall has a treatment system. As such, there are no pathways for COPC to intersect groundwater that could potentially be used for drinking water and therefore the groundwater pathway was not evaluated.

None of the COPC identified at the site are volatile; therefore, exposure *via* inhalation of volatile vapours was not evaluated.

Although inhalation of airborne respirable dust is anticipated to be *"insignificant relative to direct ingestion of soil and water, and to dermal contact"* (Health Canada 2009b) this pathway was considered in the assessment as a conservative measure.

Figure 3.7 Conceptual Site Model for Humans



3.2.3 Receptor Characteristics

Dietary data from a regional survey of First Nations people in the Yukon were used to define the dietary characteristics for campers who would be present at the historic Keno Hill Mine site. Other exposure data, such as drinking water consumption and body weight, were obtained from a survey of the general Canadian population and are acceptable for use in the current assessment.

The dietary characteristics for the assessment were based on a study of Yukon First Nations communities in 1998 (Receveur *et al.* 1998). It is acknowledged that this information was not collected for the purposes of this assessment; however, it is the best information available at present for conducting this assessment. Assumptions regarding the intakes of the adult, teen, child and toddler receptors are outlined below.

3.2.3.1 Food Consumption

Traditional and market food intake rates for the FNNND were derived from Receveur *et al.* (1998). The use of region-specific dietary intake rates was deemed more appropriate than the use of other data sources and methods to estimate traditional and market food intakes, and is associated with less uncertainty.

Receveur *et al.* (1998) collected dietary intake data using methods including food frequency questionnaires and 24-hour recall surveys administered by trained interviewers during the late winter and fall of 1995. Ten communities in the Yukon participated in the study, including Dawson City, Mayo, Carmacks, Ross River, Watson Lake, Lower Post, Beaver Creek, Burwash Landing, Carcross and Atlin. Only adults in the communities were sampled, and included both men and women divided into age categories including ages 20-40, ages 41-60 and 61+ years.

Traditional food intake rates were available for both consumers only (people who only eat traditional foods) and consumers and non-consumers (people who eat a mixture of store bought food and traditional food). Rates for consumers and non-consumers provide an average estimate for the community, while rates for consumers only provide an upper bound on the average estimate for the community. Intake rates for both groups were derived for this assessment.

To derive average traditional food intake rates for an adult at Keno Hill Mine, rates provided by Receveur *et al.* (1998) were first averaged for both sexes over the three adult age groups for which data were available. Traditional food items were subsequently grouped into categories including meat and poultry, fish, and berries in order to calculate intake rates for these based on a summation of the group items. The food groupings chosen were those typically used in Canadian total diet studies (Richardson 1997, Health Canada 2005).

Traditional food items in the meat and poultry group contained some items for which concentrations of COPC cannot be estimated in the risk assessment, such as moose bone marrow and heart. The amount consumed of each of these items was counted nonetheless so as not to under-estimate intake of traditional foods. However, it was assumed that the metals content of these items was the same as that in the flesh of the animal under consideration; this would provide an underestimate of the COPC intake as organs generally contain higher concentrations of COPC. A sensitivity analysis (Section 6.3) was performed using available measured moose kidney and liver data to determine the effect of organ consumption.

The intakes for a toddler and child were estimated assuming that the ratio of toddler to adult (0.52 meat and eggs; 0.50 fish and shellfish; 0.96 fruits and juices) and child to adult (0.74 meat and eggs; 0.81 fish and shellfish; 1.09 fruits and juices) intakes of a particular category of food for the general population (Richardson 1997) could be applied to the information for the FNNND. The intakes for a teen were conservatively assumed to be equal to that for an adult.

Table 3.3 provides the average traditional food intake rates (people who eat traditional food and a mixture of store bought food) derived from Receveur *et al.* (1998) for a Yukon First Nations adult, teen, child and toddler.

Total meat and fish intake rates were derived for risk assessment purposes, as well as fractions of these intake rates attributable to different traditional foods. This rate is presented in Table 3.3 and the fractions are presented in Table 3.4.

Table 3.3 Intake of Traditional Foods for Yukon First Nations

Food Category	Mean Intake Rate (g/d)		
	Toddler	Child	Teen/Adult
Meat and poultry	90	128	173
Fish and shellfish	10.8	17.5	21.6
Total meat and fish	101	145	195
Fruit	1.56	1.78	1.63

Notes: From Receveur *et al*. 1998

Table 3.4 Composition of Different Fractions of Meat and Fish Intake for Yukon First Nations

Traditional Food Item	Dietary Fraction
Fraction that is caribou	0.06
Fraction that is beaver*	0.02
Fraction that is dall sheep	0.004
Fraction that is fish	0.11
Fraction that is grouse	0.003
Fraction that is hare**	0.03
Fraction that is hoary marmot**	0.02
Fraction that is moose	0.75
Fraction that is waterfowl	0.002

Notes: From Receveur *et al*. 1998; fraction of total meat and fish intake
* Beaver consumption rate assumed to be reported total of beaver + porcupine meat
** Hoary marmot assumed to be 40% of hare consumption rate, and hare is 60%

Table 3.5 provides the traditional food intake rates for consumers only derived from Receveur *et al*. (1998) for a Yukon First Nations adult, teen, child and toddler. Again, a total meat and fish intake rate was also derived for risk assessment purposes, as well as fractions of the intake rate attributable to different traditional foods. The fractions are presented in Table 3.6.

Table 3.5 Intake of Traditional Foods for Yukon First Nations (Consumers of Traditional Food Only)

Food Category	Mean Intake Rate (g/d)		
	Toddler	Child	Teen/Adult
Meat and poultry	1971	2804	3790
Fish and shellfish	1043	1690	2086
Fruit	1541	738	677
Total meat and fish	3014	4494	5876

Source: Receveur *et al*. 1998

Table 3.6 Composition of Different Fractions of Meat and Fish Intake for Yukon First Nations (Consumers of Traditional Food Only)

Traditional Food Item	Dietary Fraction
Fraction that is caribou	0.05
Fraction that is moose	0.36
Fraction that is dall sheep	0.03
Fraction that is hare	0.04
Fraction that is hoary marmot	0.02
Fraction that is poultry	0.05
Fraction that is beaver	0.11
Fraction that is fish	0.36

Source: Receveur *et al*. 1998

Intake rates for commercial market foods were also available in Receveur *et al*. (1998). Similar to the methods used for the intakes of traditional foods, adults of different age groups were interviewed regarding their consumption of market food using 24-hour dietary recall surveys conducted by trained interviewers during the late winter and fall of 1995. Intake rates for individual market food items for consuming and non-consuming adults of different age groups and sexes were subsequently calculated by Receveur *et al*. (1998).

To derive average market food intake rates for an adult at the historic Keno Hill Mine, rates by Receveur *et al.* (1998) for the Yukon First Nations were first averaged for both sexes over the three adult age groups for which data were available. Market food items were then grouped into their respective food categories, which included milk and dairy products, meat and poultry, fish and shellfish, soups, bakery goods and cereals, vegetables, fruits and fruit juices, fats and oils, sugar and candies, beverages and miscellaneous items based on a summation of individual items in the group. The food groupings chosen were those typically used in Canadian total diet studies (Richardson 1997, Health Canada 2005). Market foods intake rates were only available for consumers and non-consumers combined (zeros in).

Again, the intakes for a toddler and a child were estimated assuming that the ratio of toddler to adult and child to adult of a particular category of food for the general population (Richardson

1997) could be applied to the information for the FNNND. The teen intakes were assumed to be the same as those for the adult.

Table 3.7 provides the market food intake rates derived from Receveur *et al.* (1998) for a Yukon First Nations adult, child and toddler.

Table 3.7 Intake of Market Foods Based on the Yukon First Nations

Food Category	Mean Intake Rate of Market Foods (g/d)		
	Toddler	Child	Teen/Adult
Milk and dairy products	70	52	70
Meat and poultry	178	132	178
Fish and shellfish	3.5	2.6	3.5
Soups	141	104	141
Bakery goods and cereals	185	137	185
Vegetables	193	143	193
Fruit and fruit juices	63	68	63
Fats and oils	19	14	19
Sugar and candies	34	25	34
Beverages	1379	1021	1379
Miscellaneous	76	56	76

Source: Receveur *et al.* 1998

As a significant amount of the beverage intake is coffee and tea, the beverage intakes for the child and toddler are likely overstated.

In this assessment, the dietary intakes for people who eat a mixture of traditional foods and store bought foods will be used (Table 3.3 and Table 3.4) as this seems indicative of the community around the historic Keno Hill Mine site.

3.2.3.2 Medicinal Tea Intake

Based on community consultation, EDI prepared a list of plant species and portions harvested by FNNND for medicinal purposes (Table 2 of EDI 2009). Of the species listed, measured concentrations of metals in plant tissue were available for bog blueberry (leaf and berry), prickly rose (berry) and Labrador tea (leaf). Although data were available for other species such as scrub birch, willow and alder, the data pertained to browse (i.e., twigs) and not the parts traditionally consumed by FNNND (i.e., leaf, bark). As such, in addition to the berry ingestion rate discussed previously, an intake rate for Labrador tea was developed.

The Yukon dietary survey (Receveur *et al.* 1998) indicated that in the winter 12% of the study group consumes the Labrador tea plant 1.2 times per week and in the summer 23% of the study group consumes the plant 1.4 times per week. This equates to an average Labrador tea plant consumption rate of 1.3 days per week. The survey does not, however, provide the amount of Labrador tea beverage, or other medicinal teas, that are consumed.

In an attempt to determine the amount of medicinal tea consumed by members of the community, a web search was undertaken. The web search indicated that "*Labrador Tea contains small amounts of the toxin andromedotoxin which can cause headaches, cramps, paralysis and intestinal problems if too much is consumed. As a general rule, this tea should be consumed in moderation. One cup is often considered the safe amount.*" - *http://www.laurentiancenter.com/plantkey/plants/labradortea.html*

Therefore, it was assumed that the consumption rate of Labrador tea of 1.3 days per week was suitable to be used as the number of cups (250 mL) of medicinal tea consumed per week for an adult. This equates to a medicinal tea consumption rate of approximately 0.19 cups per day (0.046 mL per day). There was no information available on the amount of fresh Labrador tea leaves used in the brewing process. In this assessment, it was assumed that approximately 3 g are used. A typical, commercially available tea bag has a mass of approximately 2 g; therefore the assumption that 3 g of Labrador tea leaves are used per cup of tea is reasonable.

Receveur *et al.* (1998) also provides frequencies and percents of the study group consuming other medicinal plants, such as birch and willow. Although data were not available for the parts typically consumed by FNNND, a sensitivity analysis was conducted on medicinal tea intake using data for birch and willow (see Section 6.3). From Receveur *et al.* (1998), the average rate of consumption of birch and willow is 0.85 day per week (Table 3.8). To be conservative, the same medicinal tea intake rate developed for Labrador tea (0.19 cups per day) was used.

Table 3.8 Frequency of Consumption of Birch and Willow

Plant species	Season	% of Population	Frequency (days/week)
Birch	Winter	3	0.7
	Summer	4	0.9
Willow	Winter	1	1.2
	Summer	5	0.6

Source: Receveur *et al.* 1998

3.2.3.3 Water Intake

The water intakes for an adult and child were obtained from the *Compendium of Canadian Human Exposure Factors for Risk Assessment* (Richardson 1997). The average water intakes for an adult (20+ years of age), teen (12 to 19 years of age), child (5 to 11 years of age) and toddler (0.5 to 4 years of age) are estimated to be 1.5 L/d, 1 L/d, 0.8 L/d and 0.6 L/d, respectively.

3.2.3.4 Soil Intake

Soil intake rates are available from Health Canada (2009b). However, the Contaminated Sites Division (CSD) of Health Canada has undertaken to re-evaluate soil ingestion rates and to define these as log-normal probability density functions (distributions) (Richardson 2010).

It is broadly acknowledged among professional risk assessors that the assumed rates of soil ingestion currently used for risk assessment significantly over-estimate actual exposure from this environmental medium. Also, the assumptions concerning soil ingestion currently employed and recommended for risk assessment by Health Canada (2009b) are not associated in any way with the amount of time spent in the outdoor environment. As a result, the same assumed rate of soil ingestion is applied whether a hypothetical receptor is assumed to be outdoors for 10 minutes or 10 hours. However, with the exception of children exhibiting pica behaviour, it is logical to expect that the amount of soil ingested, and certainly the likelihood that soil ingestion would actually occur, would be greater if that receptor were outdoors 10 hours versus 10 minutes (Richardson 2010).

Based on methods originally developed for estimation of indoor settled dust ingestion rates (WTCWG 2003), and accounting for various factors such as time spent outdoors, soil adherence to hands, rates of hand-to-mouth activity, surface area of hands, etc., the CSD (unpublished) has developed distributions for soil ingestion rates as well as correlation coefficients between soil ingestion rate and time spent out of doors (Richardson 2010). The average values for the adult, teen, child and toddler of 1.7 mg/d, 1.5 mg/d, 1.2 mg/d and 1.3 mg/d, respectively, were used in this assessment.

3.2.3.5 Inhalation Rate

The inhalation of outdoor air is required to estimate the intake of metals adsorbed to respirable dust. The average inhalation rates reported Allan *et al*. (2008) for the adult, teen, child and toddler of 16.6 m^3/d, 15.6 m^3/d, 14.5 m^3/d and 8.3 m^3/d, respectively, were used in the assessment.

3.2.3.6 Dermal Contact Intake Rate

Intake of COPC can occur *via* dermal contact with contaminated soil. Exposed skin surface areas (hands, arms and legs) for the adult, teen, child and toddler of 9110 cm^2, 8000 cm^2, 5140 cm^2 and 3010 cm^2, respectively, were obtained from Richardson (1997). Single point estimates for soil loading to exposed skin were obtained from Health Canada (2009b), while the exposure frequency was assumed to be the same as the time on site (i.e., 1.5 months pear year).

3.2.3.7 Body Weight

The body weights (bw) of a toddler, child, teen and adult are also necessary in order to calculate daily intake rates (mg/(kg (bw) d)). In this assessment, the body weights used for the toddler, child, teen and adult receptors were 16.5 kg, 32.9 kg, 59.7 kg and 70.7 kg, respectively (Richardson 1997).

3.2.3.8 Summary of Receptor Characteristics

The nominal amounts of traditional foods and berries that will be assumed to be consumed by the adult, teen, child and toddler receptors present at the historic Keno Hill Mine site are summarized in Table 3.9. All receptors were assumed to be on site a total of 1.5 months per year, but consumed food obtained from the area six months of the year.

Table 3.9 Air, Water, Soil and Local Food Intake Rates Used in the Pathways Modelling

Receptor Characteristic	Receptor			
	Adult	**Teen**	**Child**	**Toddler**
Water (L/d)	1.5	1.0	0.8	0.6
Soil Intake (mg dw/d)	1.7	1.5	1.2	1.3
Inhalation Rate (m^3/d)	16.6	15.6	14.5	8.3
Local Meat (g ww/d)				
Caribou	11.8	11.8	8.7	6.1
Moose	146	146	108	75.9
Sheep	0.68	0.68	0.50	0.35
Hare	6.1	6.1	4.5	3.2
Hoary Marmot	4.1	4.1	3.0	2.1
Beaver	3.3	3.3	2.5	1.7
Local Poultry (g ww/d)				
Ground Birds (Spruce Grouse)	0.67	0.67	0.50	0.34
Waterfowl	0.33	0.33	0.24	0.17
Local Fish (g ww/d)				
Total Local Meat, Fish and Poultry (g ww/d)	195	195	145	101
Other (g ww/d)				
Berries	1.6	1.6	1.8	1.6
Labrador Tea	0.56	0.56	0	0
Exposed Skin Surface Area (cm^2)	9110	8000	5140	3010
Soil Loading to Exposed Skin (kg/(cm^2-event))	1.88×10^{-8}	1.90×10^{-8}	2.03×10^{-8}	2.29×10^{-8}

Notes: Adult Weight = 70.7 kg; Teen = 59.7 kg; Child Weight = 32.9 kg; Toddler = 16.5 kg

4.0 EXPOSURE ASSESSMENT

This section details the procedure used to estimate exposure to the COPC for the various ecological and human receptors, and summarizes the results of the assessment.

4.1 EXPOSURE LOCATIONS

The historic Keno Hill Mine site covers a large area with different areas of concern, and it is therefore not reasonable to assume that receptors which may be present in different areas will be exposed to the same levels COPC. As such, the site was divided into different exposure locations in order to determine which areas may pose the greatest concern to human and ecological health.

4.1.1 Aquatic Receptors

The aquatic assessment was conducted for a total of 12 exposure locations (including background), which were selected based on water and sediment data availability and to provide a variety of possible exposure scenarios for evaluation. The locations for the aquatic assessment are described as follows:

- LC - The portion of Lightning Creek flowing from just west of Charity Gulch up to Duncan Creek
- CC at Outlet of CL - The portion of Christal Creek running between the outlet of Christal Lake and the outlet of Erickson Gulch
- CC d/s of CL - The portion of Christal Creek downstream of Christal Lake, running between Erickson Gulch and its confluence with South McQuesten River
- Upper SMQR - The portion of South McQuesten River running from just upstream of the outlet of Christal Creek to Pump House Pond
- Lower SMQR - The portion of SMQR running between Pump House Pond and the outlet of Flat Creek
- BC/FC u/s of adits - Brefault and Flat Creeks upstream of their respective adits
- BC/FC d/s of adits - Brefault and Flat Creeks downstream of their respective adits
- GC u/s of adit - Galena Creek upstream of the Silver King adit
- GC d/s of adit - Galena Creek downstream of the Silver King adit
- NCC - No Cash Creek downstream of the adit
- SaC/StC - Sandy and Star Creeks
- Bkgd - Background (South McQuesten River at South McQuesten Lake, Haldane Creek, Lightning Creek upstream of Hope Gulch, Williams Creek, Field Creek)

As summarized in Table 4.1, the aquatic receptors identified in Section 3.1.1 were assumed to be present in all locations, with the exception of forage and predator fish which were assumed to not be present in the smaller, minor tributaries in the vicinity of the various adits (Brefault Creek, Flat Creek, Galena Creek, No Cash Creek, Sandy Creek, Star Creek).

Table 4.1 Aquatic Ecological Receptors Assumed For Assessment

Location	Receptor					
	Aquatic Plants	Benthic Invertebrates	Zooplankton	Phytoplankton	Forage Fish	Predator Fish
LC	✓	✓	✓	✓	✓	✓
CC at Outlet LC	✓	✓	✓	✓	✓	✓
CC d/s of CL	✓	✓	✓	✓	✓	✓
Upper SMQR	✓	✓	✓	✓	✓	✓
Lower SMQR	✓	✓	✓	✓	✓	✓
BC/FC u/s of adits	✓	✓	✓	✓	x	x
BC/FC d/s of adits	✓	✓	✓	✓	x	x
GC u/s of adit	✓	✓	✓	✓	x	x
GC d/s of adit	✓	✓	✓	✓	x	x
NCC	✓	✓	✓	✓	x	x
SaC/StC	✓	✓	✓	✓	x	x
Bkgd	✓	✓	✓	✓	✓	✓

Notes:
✓ - Species assumed to be present
X - Species assumed to not be present
LC - Lightning Creek
CC - Christal Creek
CL - Christal Lake
SMQR - South McQuesten River
BC - Brefault Creek
FC - Flat Creek
GC - Galena Creek
NCC - No Cash Creek
SaC - Sandy Creek
StC - Star Creek
Bkgd - Background

4.1.2 Terrestrial Receptors

The terrestrial assessment was conducted for a total of five exposure locations, again based on data availability and to provide a variety of possible exposure scenarios for evaluation. For smaller receptors with small home ranges, such as the hare, a different hare was evaluated for each location while for larger receptors with large home ranges, such as the moose, exposure was evaluated site-wide (Keno Hill Mine [UKHM]). The five locations are described as follows:

- GH - the south-east side of Galena Hill, in the vicinity of Lightning Creek
- MT - the area directly around Christal Lake, in the vicinity of the Mackeno Tailings
- VT - the area around the Elsa Valley tailings, encompassing the Valley Tailings, Husky Shaft SW, and No Cash
- SK - the area around the Silver King adit where Galena Creek empties into Flat Creek
- SMQ - the area around the confluence of Flat Creek with the South McQuesten River

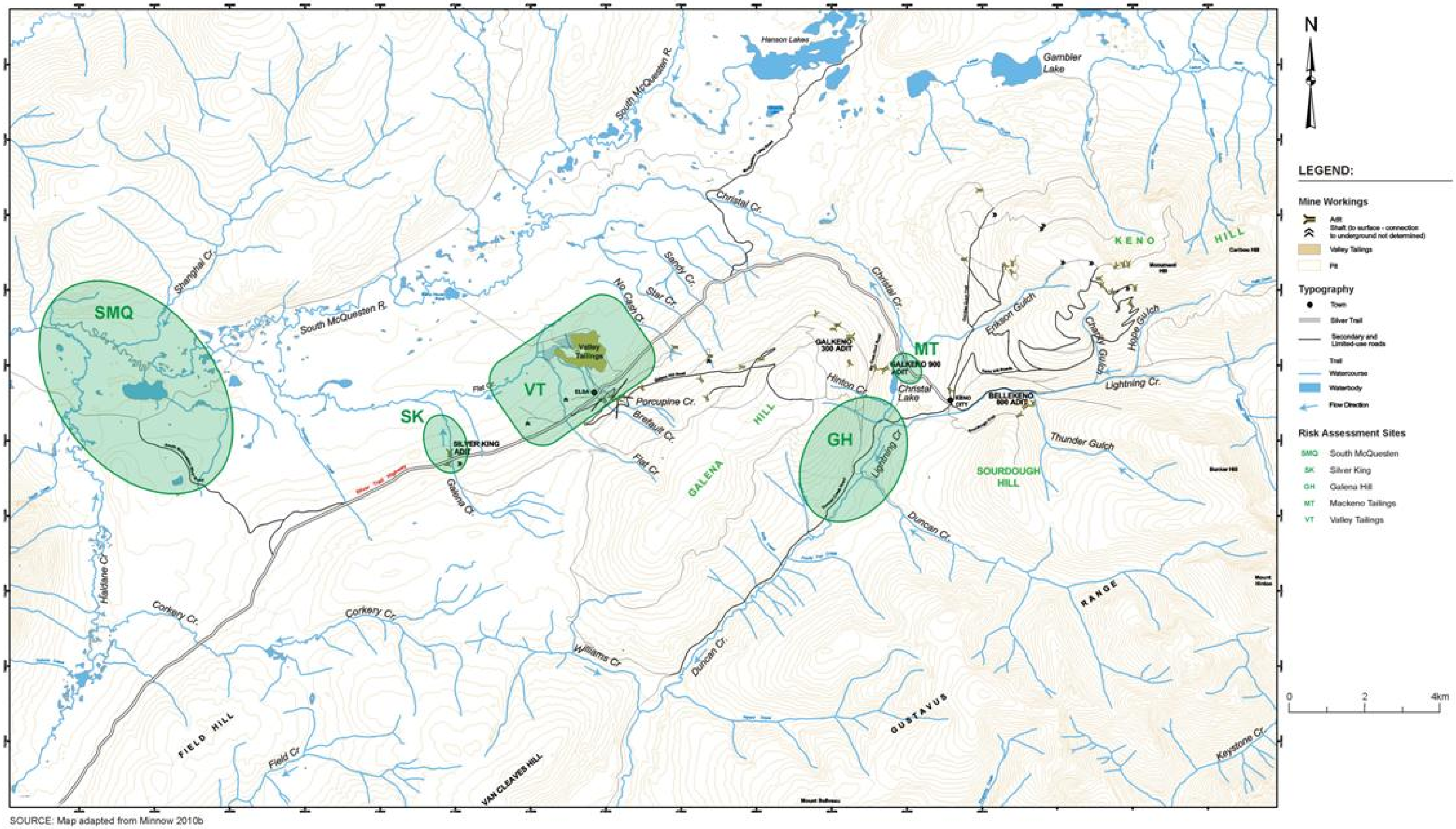
These locations are illustrated in Figure 4.1. A separate background location was not evaluated since the undisturbed ‘control’ areas for which soil and terrestrial vegetation data are available were evaluated as part of Galena Hill and South McQuesten.

No sediment data were available for the small watercourses around the Valley Tailings and thus only those receptors primarily in the terrestrial environment were evaluated at this location (i.e., not the beaver or mink). Additionally, the water courses around this area are primarily minor tributaries and therefore it is not likely that beaver or mink would spend significant amounts of time in this area. Waterfowl (mallard, merganser, scaup) were only evaluated in the Mackeno Tailings location since this area contains the largest surface water body (i.e., Christal Lake). The locations of each receptor are summarized in Table 4.2.

4.1.3 Human Receptors

The human health assessment was conducted for a total of two exposure locations, assuming that humans visiting the area for camping and hunting activities would be present largely in the South McQuesten area where Flat Creek empties into the South McQuesten River, and the Galena Hill area around Lightning Creek. These areas have been previously described for the terrestrial receptors (Section 4.1.2). As described in Section 3, there are approximately 6 to 8 year-round residents at Keno City who will be explicitly evaluated in a subsequent phase of work.

Figure 4.1 Exposure Locations Evaluated for Terrestrial Assessment



Notes: locations are approximate

Table 4.2 Terrestrial Ecological Receptor Locations

Receptor	Location					
	GH	MT	VT [a]	SK	SMQ	UKHM
Bear	-	-	-	-	-	✓
Beaver	✓	✓	x	✓	✓	x
Caribou	-	-	-	-	-	✓
Fox	✓	✓	✓	✓	✓	x
Grouse	✓	✓	✓	✓	✓	x
Hare	✓	✓	✓	✓	✓	x
Marmot	✓	✓	✓	✓	✓	x
Mink	✓	✓	x	✓	✓	x
Moose	-	-	-	-	-	✓
Sheep	✓	✓	✓	✓	✓	x
Wolf	-	-	-	-	-	✓
Waterfowl						
Mallard	x	✓	x	x	x	x
Merganser	x	✓	x	x	x	x
Scaup	x	✓	x	x	x	x

Notes:

✓	- Species assumed to be present	GH	- Galena Hill
x	- Species assumed to not be present	MT	- Mackeno Tailings
'-'	- Species evaluated across entirety of site, not only within specific locations	VT	- Elsa Valley Tailings
		SK	- Silver King
b	- Not evaluated for beaver and mink (no sediment data available, minor tributaries).	SMQ	- South McQuesten
		UKHM	- Entirety of Keno Hill area

4.2 EXPOSURE POINT CONCENTRATIONS

Preliminary Quantitative Risk Assessments (PQRAs) use maximum measured concentrations as the exposure point concentrations for receptors, which is a very conservative approach since the site characterization data collection process is biased toward determining and delineating areas of contamination, rather than areas meeting applicable generic standards. As such, the maximum measured concentrations are generally localized and do not represent true site conditions. Given that this is a Detailed Quantitative Risk Assessment, concentrations that are more statistically representative of the various locations evaluated were used. If the number of samples within a given location was less than 10 then the maximum concentration was considered to be representative of the exposure point concentration for that location. If the number of the samples was 10 or greater, then the 95% 1-sided Upper Confidence Level of the Mean (95% UCLM) was selected as the exposure point concentration and was considered to be the reasonable maximum exposure concentration. The 95% UCLM values were calculated using the U.S. EPA ProUCL 4.0 software. For COPC with a large percentage of measurements below the MDL, the 95%

UCLM was often higher than the maximum measured concentration; in these instances, the maximum value was then selected as the exposure point concentration.

In general, only data from 2000 onwards were used to develop the exposure point concentrations as these data are considered to be representative of the site in its current condition. Values below the MDL were converted to ½ the MDL before the exposure point concentrations were calculated.

4.2.1 Aquatic Assessment

Water and sediment data from the various locations were used to determine the exposure point concentrations for aquatic receptors. For sediment, data from post-2000 were available for 2004, 2007, 2008 and 2009 for one or more of the monitoring stations within the various locations. In 2008, the sampling program was focused on areas associated with barriers to fish movement in Christal Creek and on areas in Christal Lake in the vicinity of historical tailings deposits. Additionally, at the time of sampling the area had just undergone a considerable period of above normal precipitation, resulting in elevated flow rates, above normal discharge and increased turbidity (Access 2009). As such, the sediment data from the 2008 sampling program may not represent true conditions in the Mackeno Tailings location and these sediment data were not used in the development of the exposure point concentrations.

The thallium measurements collected in 2007 in sediment were at least an order of magnitude higher than the measurements collected from the same or similar locations in 2004 and 2009. No explanation could be found for these high values, especially since the water measurements from the same time period were all below the method detection limits. The same trend was not observed for other metals, such as arsenic, and it was decided that the data for thallium were likely erroneous and were removed from the data set.

There has been discussion in previous aquatic environment assessment reports regarding the accuracy and reliability of water data collected before 2005, largely as a result of higher MDLs for many constituents before this time. Also, lime treatment of the Galkeno 300 adit commenced in March 2004 and monitoring programs conducted in 2004 and 2005 indicated that Christal Creek was still showing lingering effects from the treated fugitive flow. As such, only water data collected after January 2006 were used to develop the exposure point concentrations these data provide more accurate representations of current site conditions.

The water and sediment monitoring stations which were used to develop the exposure point concentrations for the aquatic assessment are summarized in Table 4.3. Data from source stations (e.g., adits, treatment pond decant, etc.) were not used in the development of the concentrations. Sediment data from 2000 and onwards were not available for the smaller water courses (Brefault Creek, Flat Creek, Galena Creek, No Cash Creek, Sandy Creek, Star Creek) and therefore they were not evaluated for sediment toxicity. Although this adds some uncertainty to the assessment, these are small watercourses which are unlikely to provide suitable habitat for aquatic organisms such as benthic invertebrates.

Although monitoring station KV-1 has been considered a reference station in the past, since 2007 the concentrations have been increasing as a result of loads from Cache Creek. As such, KV-1 was not considered a reference station for the exposure assessment. In addition to the data provided in the water quality database, data were also provided from September 2009 separately for several areas (Tremblay, pers. comm. 2011). While most of the sampling locations could be linked to existing water monitoring stations, two locations could not ("flow near Star Creek/Christal Creek", and "flow between McQuesten Lake Road/Sandy Creek"); it was assumed that these locations could be considered to be from Sandy Creek and Star Creek. The final exposure point concentrations used for the aquatic assessment are summarized in Table 4.4 for water and Table 4.5 for sediment.

Table 4.3 Monitoring Stations Used to Develop Exposure Point Concentrations for Aquatic Assessment

Location	Monitoring Station	
	Water (1)	Sediment (2)
LC	KV-38, KV-41	KV-38, KV-41
CC at Outlet LC	KV-6, KV-16, KV-30	KV-6
CC d/s of CL	KV-7, KV-8	KV-7, KV-8
Upper SMQR	KV-1, KV-2	KV-1, KV-2
Lower SMQR	KV-3, KV-4, KV-9	KV-3, KV-4, KV-9
BC/FC u/s of adits	KV-61, 64	NE
BC/FC d/s of adits	KV-62, 63	NE
GC u/s of adit	KV-60	NE
GC d/s of adit	KV-59	NE
NCC	KV-21	NE
SaC/StC	KV-55, KV-56 (3)	NE
Bkgd	KV-37, KV-57, KV-72 (4)	KV-37

Notes: All values <MDL converted to ½ the MDL

NE Not evaluated; sediment data not available and small watercourse with limited aquatic habitat

1 Water quality data from January 2006 and onwards

2 Sediment quality data from 2004, 2007 and 2009 (thallium data from 2007 omitted)

3 Includes September 2009 "flow near Star Creek/Christal Creek", and "flow between McQuesten Lake Road/Sandy Creek"

4 Includes Williams Creek and Field Creek

LC	Lightning Creek	BC	Brefault Creek	SaC	Sandy Creek
CC	Christal Creek	FC	Flat Creek	StC	Star Creek
CL	Christal Lake	GC	Galena Creek	Bkgd	Background
SMQR	South McQuesten River	NCC	No Cash Creek		

Table 4.4 Summary of Exposure Point Concentrations for Aquatic Assessment - Water

COPC	Soil Exposure Point Concentration (mg/L)											
	LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	BC/FC u/s of adits	BC/FC d/s of adits	GC u/s of adit (a)	GC d/s of adit (a)	NCC	SaC/StC	Bkgd
Antimony	6.5x10^{-4}	1.6x10^{-3}	4.9x10^{-4}	2.4x10^{-4}	2.9x10^{-3}	1.0x10^{-3}	5.6x10^{-4}	1.2x10^{-3}	9.0x10^{-4}	1.5x10^{-3}	5.9x10^{-4}	4.8x10^{-4}
Arsenic	1.6x10^{-2}	1.5x10^{-2}	4.9x10^{-3}	1.9x10^{-3}	8.8x10^{-3}	5.8x10^{-3}	6.2x10^{-3}	6.6x10^{-3}	3.0x10^{-3}	5.8x10^{-3}	4.1x10^{-3}	1.7x10^{-2}
Cadmium	2.3x10^{-4}	2.6x10^{-3}	1.3x10^{-3}	6.6x10^{-4}	7.9x10^{-4}	1.0x10^{-2}	2.3x10^{-3}	5.9x10^{-4}	9.6x10^{-4}	1.8x10^{-2}	1.9x10^{-2}	6.3x10^{-4}
Chromium	3.3x10^{-3}	1.8x10^{-3}	1.6x10^{-3}	9.3x10^{-4}	9.0x10^{-4}	2.2x10^{-3}	3.2x10^{-3}	1.9x10^{-3}	2.3x10^{-3}	1.6x10^{-3}	3.9x10^{-3}	6.1x10^{-4}
Cobalt	2.3x10^{-3}	1.4x10^{-3}	5.8x10^{-4}	4.5x10^{-3}	1.9x10^{-3}	1.2x10^{-3}	1.7x10^{-3}	6.0x10^{-4}	8.0x10^{-4}	1.3x10^{-3}	2.3x10^{-3}	2.4x10^{-4}
Copper	1.1x10^{-2}	5.2x10^{-3}	3.8x10^{-3}	5.7x10^{-3}	5.2x10^{-3}	4.4x10^{-3}	9.5x10^{-3}	6.0x10^{-3}	5.0x10^{-3}	6.0x10^{-3}	5.8x10^{-3}	1.9x10^{-3}
Iron	4.3	2.0	1.0	6.0x10^{-1}	1.4	1.9	3.1	1.2	1.5	1.1	5.0	5.1x10^{-1}
Lead	4.7x10^{-2}	2.2x10^{-2}	8.9x10^{-3}	1.5x10^{-3}	9.4x10^{-2}	4.8x10^{-3}	9.6x10^{-3}	3.2x10^{-2}	3.2x10^{-3}	2.9x10^{-2}	4.7x10^{-3}	4.9x10^{-4}
Manganese	8.0x10^{-2}	0.96	0.25	0.19	0.45	2.2	2.4	8.0x10^{-2}	0.12	1.4	1.4	5.8x10^{-2}
Mercury	1.0x10^{-5} (a)	1.0x10^{-5} (a)	1.0x10^{-5} (a)	ND	2.0x10^{-5} (a)	ND	1.0x10^{-4} (a)	ND	ND	1.0x10^{-5} (a)	1.0x10^{-4} (a)	5.0x10^{-6} (a)
Molybdenum	5.6x10^{-4}	6.2x10^{-4}	5.4x10^{-4}	7.0x10^{-4}	6.9x10^{-4}	4.9x10^{-4}	5.0x10^{-4} (b)	1.1x10^{-3}	5.0x10^{-4}	4.9x10^{-4}	5.0x10^{-4} (b)	5.0x10^{-4} (b)
Nickel	5.0x10^{-3}	6.4x10^{-3}	3.4x10^{-3}	3.0x10^{-2}	1.1x10^{-2}	5.2x10^{-3}	4.4x10^{-3}	3.0x10^{-3}	4.1x10^{-3}	9.8x10^{-3}	1.0x10^{-2}	2.0x10^{-3}
Selenium	6.6x10^{-4}	1.1x10^{-3}	9.3x10^{-4}	5.1x10^{-4}	4.6x10^{-4}	7.3x10^{-4}	8.6x10^{-4}	1.1x10^{-3}	3.0x10^{-4}	9.9x10^{-4}	3.9x10^{-4}	5.2x10^{-4}
Silver	7.9x10^{-4}	7.3x10^{-4}	1.2x10^{-4}	8.3x10^{-5}	1.2x10^{-3}	1.7x10^{-4}	3.6x10^{-4}	1.0x10^{-3}	9.0x10^{-5}	5.2x10^{-4}	5.8x10^{-5}	4.6x10^{-5}
Strontium	8.7x10^{-2}	0.33	0.24	0.24	0.21	0.27	0.50	0.21	0.26	0.36	9.7x10^{-2}	0.18
Uranium	6.3x10^{-4}	4.5x10^{-3}	3.0x10^{-3}	8.3x10^{-4}	1.1x10^{-3}	1.5x10^{-3}	1.8x10^{-3}	1.7x10^{-3}	2.2x10^{-3}	6.1x10^{-3}	1.9x10^{-3}	1.2x10^{-3}
Vanadium	4.8x10^{-3}	2.5x10^{-3}	1.3x10^{-3}	9.7x10^{-4}	7.6x10^{-4}	3.4x10^{-3}	6.0x10^{-3}	2.3x10^{-3}	3.0x10^{-3}	2.1x10^{-3}	1.6x10^{-2}	5.7x10^{-4}
Zinc	3.7x10^{-2}	0.65	0.29	0.13	8.9x10^{-2}	0.91	0.30	3.4x10^{-2}	4.4x10^{-2}	2.0	0.73	6.2x10^{-2}

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL
ND No data available for location; not evaluated

LC	Lightning Creek	BC	Brefault Creek	SaC	Sandy Creek	d/s	downstream
CC	Christal Creek	FC	Flat Creek	StC	Star Creek	a	Maximum (N<10)
CL	Christal Lake	GC	Galena Creek	Bkgd	Background	b	Maximum (95% UCLM > maximum)
SMQR	South McQuesten River	NCC	No Cash Creek	u/s	upstream		

Table 4.5 Summary of Exposure Point Concentrations for Aquatic Assessment - Sediment

COPC	Sediment Exposure Point Concentration (mg/kg dw)					
	LC	CC at Outlet of CL (a)	CC d/s of CL	Upper SMQR	Lower SMQR	Bkgd (a)
Antimony	9.8	97	12	18 (b)	86	2.2
Arsenic	351	1750	144	194	255	192
Cadmium	20	177	34	13	42	3.9
Chromium	26	19	16	15	15	24
Cobalt	11	56	11	22	17	14
Copper	40	88	41	36	145	47
Iron	26740	67100	26029	22312	49011	34400
Lead	408	4450	687	713 (b)	2931	44
Manganese	1492	48100	3932	2895	11151	1210
Mercury	0.24 (a)	0.11 (a)	0.12	0.13 (a)	0.47	0.097
Molybdenum	3.3	2.5	1.8	1.3	1.5	1.7
Nickel	31	108	36	81	58	34
Selenium	2.5 (b)	3.1	2.4	1.9	4.8	1.8
Silver	10	13	333	14 (b)	13	0.90
Strontium	17	34	61	34	31	21
Uranium	0.91 (a)	7.6 (a)	244 (a)	1.7 (a)	1.5 (a)	1.2
Vanadium	25	32	25	22	25	34
Zinc	1084	15200	2555	987	1861	129

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL

LC	Lightning Creek	SMQR	South McQuesten River	d/s	downstream
CC	Christal Creek	Bkgd	Background	a	Maximum (N<10)
CL	Christal Lake	u/s	upstream	b	Maximum (95% UCLM >maximum)

4.2.2 Terrestrial Evaluation

For the terrestrial assessment, exposure point concentrations were determined for all exposure media to which terrestrial receptors are for each of the five locations and site-wide (UKHM). For terrestrial vegetation, the concentrations were converted from a dry weight basis to a wet weight basis using either the reported sample moisture contents or typical values of 70% (berries, browse, forage) or 40% (moss/lichen).

The soil and vegetation data for the terrestrial evaluation were obtained from the Phase 1, 2 and 3 reports written by EDI (EDI 2008, 2009, 2010). Of the soil data, the sampling locations were not provided for samples 7, 8, 9, 10, 11 and 12; as such, these data were only used in the development of the site-wide exposure point concentrations. The samples Z1, Z2, and Z3 were omitted from the 2009 soil data set as these samples represent tailings and not actual soil samples. In the Phase 3 assessment, EDI determined that samples E01, S02 and Pit 22 were outliers (EDI 2010). However, in this assessment these samples were retained in the data set since vegetation data were obtained from each of these locations. Although Minto Bridge is quite a distance from the historic Keno Hill Mine site, moose and caribou have large home ranges and therefore may consume vegetation from this area. As such, the vegetation data from Minto Bridge were included in the data set used to develop exposure point concentrations for site-wide receptors (e.g., moose).

At the time of preparation of this report, berries data were not available for the Silver King area. Data are expected to be available after additional work is conducted during 2011 and 2012 and may be incorporated in a subsequent assessment. Due to the proximity to the Elsa Valley Tailings, the berries concentrations from the Valley Tailings were used as surrogates. Similarly, soil concentrations were not available for the Mackeno Tailings area and thus data for nearby Galena Hill were used. Berries data were also not available for the Galena Hill area. Since this area is considered to be an undisturbed ‘control’ area, data from the nearby Mackeno Tailings area may not reflect the concentrations at Galena Hill. A statistical analysis was conducted in order to determine whether it would be appropriate to use the berries data from the other ‘control’ site, South McQuesten. Concentrations in willow, scrub birch and Labrador tea were compared in order to determine if the concentrations of metals in these species were statistically different between the South McQuesten and Galena Hill areas. Using the Wilcoxon two-sample test (two-sided with t approximation), a non-parametric statistical test which makes no assumption on the distribution of data, it was determined that for the most part the measurements were not statistically different at a 5% significance level. In cases where there was a statistical difference between the measurements, the South McQuesten data were higher. Thus, the use of the South McQuesten berries data as surrogate data for the Galena Hill location is appropriate and will likely not underestimate exposure to terrestrial receptors.

Similar to the aquatic assessment, water data from 2006 and onwards and sediment data from 2004, 2007 (with the exception of thallium data) and 2009 were used in the assessment. Data from source stations were not used. When sediment data were not available for a location, literature water-to-sediment transfer factors (K_d values) were used to estimate sediment concentrations. The K_d values are discussed in more detail in Section 4.3.1. Concentrations of COPC in fish tissue and whole fish samples were used in the terrestrial assessment. Only data from 2000 onwards were included in the data set. When fish data were not available for a location, water-to-fish transfer factors (TFs) were used to estimate fish tissue concentrations. The water-to-fish TFs used in the assessment are discussed in more detail in Section 4.3.1.

A number of the terrestrial receptors consume aquatic vegetation, but no measured data of COPC in this medium were available. As such, water-to-aquatic vegetation TFs from literature were used to estimate exposure point concentrations for aquatic vegetation. Again, these TFs are discussed in more detail in Section 4.3.1.

The data used to develop the exposure point concentrations are summarized in Table 4.6, while the final exposure point concentrations are summarized in Table 4.7 to Table 4.15.

Table 4.6 Data used to Develop Exposure Point Concentrations for Terrestrial Assessment

Receptor	Area	Exposure Medium													
		Water [a]	**Sediment [b]**	**Soil [c]**	**Forage [c]**	**Browse [c]**	**Lichen [d]**	**Berries [c]**	**Aq. Veg.**	**Ben-thics**	**Fish [e]**	**Water-fowl**	**Hare**	**Caribou**	**Moose**
Bear	UKHM	All data		All data [j]	All data			All data			All data [e]			Max calc	Max calc
Beaver	GH	KV-38, KV-41, KV-48, KV-49, KV-50, KV-51	KV-38, KV-41			GH data			TF						
	MT	KV-6, KV-16, KV-30	KV-6			MT data			TF						
	SK	KV-59, KV-60	K_d			SK data			TF						
	SMQ	KV-3, KV-4, KV-9	KV-3, KV-4, KV-9			SK data			TF						
Caribou	UKHM	All data [a]		All data [j]	All data	All data	All data		TF						
Fox	GH	KV-38, KV-41, KV-48, KV-49, KV-50, KV-51		GH data				SMQ data [f]				Max calc	Max calc		
	MT	KV-6, KV-16, KV-30		GH data [g]				MT data				Max calc	Max calc		
	VT	KV-21, KV-55, KV-56, KV-61, KV-62, KV-63, KV-64 [h]		Elsa, NC data				Elsa data				Max calc	Max calc		
	SK	KV-59, KV-60		SK data				Elsa data [i]				Max calc	Max calc		
	SMQ	KV-3, KV-4, KV-9		SMQ data				SMQ data				Max calc	Max calc		
Grouse	GH	KV-38, KV-41, KV-48, KV-49, KV-50, KV-51		GH data		GH data		SMQ data [f]							
	MT	KV-6, KV-16, KV-30		GH data [g]		MT data		MT data							
	VT	KV-21, KV-55, KV-56, KV-61, KV-62, KV-63, KV-64 [h]		Elsa, NC data		Elsa, NC and HSW data		Elsa data							
	SK	KV-59, KV-60		SK data		SK data		Elsa data [i]							
	SMQ	KV-3, KV-4, KV-9		SMQ data		SMQ data		SMQ data							

Table 4.6 Data used to Develop Exposure Point Concentrations for Terrestrial Assessment (Cont'd)

Receptor	Area	Exposure Medium													
		Water [(a)]	Sediment [(b)]	Soil [(c)]	Forage [(c)]	Browse [(c)]	Lichen [(d)]	Berries [(c)]	Aq. Veg.	Ben-thics	Fish [(e)]	Water-fowl	Hare	Caribou	Moose
Hare	GH	KV-38, KV-41, KV-48, KV-49, KV-50, KV-51		GH data	GH data	GH data									
	MT	KV-6, KV-16, KV-30		GH data [(g)]	MT data	MT data									
	VT	KV-21, KV-55, KV-56, KV-61, KV-62, KV-63, KV-64 [(h)]		Elsa, NC data	Elsa, NC and HSW data	Elsa, NC and HSW data									
	SK	KV-59, KV-60		SK data	SK data	SK data									
	SMQ	KV-3, KV-4, KV-9		SMQ data	SMQ data	SMQ data									
Marmot	GH	KV-38, KV-41, KV-48, KV-49, KV-50, KV-51		GH data	GH data										
	MT	KV-6, KV-16, KV-30		GH data [(g)]	MT data										
	VT	KV-21, KV-55, KV-56, KV-61, KV-62, KV-63, KV-64 [(h)]		Elsa, NC data	Elsa, NC and HSW data										
	SK	KV-59, KV-60		SK data	SK data										
	SMQ	KV-3, KV-4, KV-9		SMQ data	SMQ data										
Mink	GH	KV-38, KV-41, KV-48, KV-49, KV-50, KV-51	KV-38, KV-41						TF	TF	KV-41, LCD	Max calc	Max calc		
	MT	KV-6, KV-16, KV-30	KV-6						TF	TF	CL, KV-6	Max calc	Max calc		
	SK	KV-59, KV-60	K_d						TF	TF	TF	Max calc	Max calc		
	SMQ	KV-3, KV-4, KV-9	KV-3, KV-4, KV-9						TF	TF	KV-4, KV-9	Max calc	Max calc		
Moose	UKHM	All data [(a)]	All data [(b)]	All data [(j)]		All data			TF						

Table 4.6 Data used to Develop Exposure Point Concentrations for Terrestrial Assessment (Cont'd)

Receptor	Area	Exposure Medium													
		Water [(a)]	Sediment [(b)]	Soil [(c)]	Forage [(c)]	Browse [(c)]	Lichen [(d)]	Berries [(c)]	Aq. Veg.	Ben-thics	Fish [(e)]	Water-fowl	Hare	Caribou	Moose
Sheep	GH	KV-38, KV-41, KV-48, KV-49, KV-50, KV-51		GH data	GH data										
	MT	KV-6, KV-16, KV-30		GH data [(g)]	MT data										
	VT	KV-21, KV-55, KV-56, KV-61, KV-62, KV-63, KV-64 [(h)]		Elsa, NC data	Elsa, NC and HSW data										
	SK	KV-59, KV-60		SK data	SK data										
	SMQ	KV-3, KV-4, KV-9		SMQ data	SMQ data										
Wolf	UKHM	All data [(a)]		All data [(j)]									Max calc	Max calc	Max calc
Waterfowl															
Mallard	MT	KV-6, KV-16, KV-30	KV-6						TF	TF					
Merganser	MT	KV-6, KV-16, KV-30	KV-6								CL, KV-6				
Scaup	MT	KV-6, KV-16, KV-30	KV-6						TF	TF					

Notes:

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area
CL Christal Lake
NC No Cash
HSW Husky Shaft SW
TF Transfer factor
K_d Water-to-sediment transfer factor

a Water data from January 2006 onwards; source data (e.g., adits, tailings pond decant) omitted
b Sediment data from 2004, 2007 (thallium data omitted) and 2009
c Data from 2008, 2009 and/or 2010; data from samples obtained directly from the tailings (Z1, Z2, Z3) omitted
d Evaluated site-wide for caribou exposure; data for lichen (2007, 2008) and moss (2008)
e Whole fish and fish tissue samples from 2006 and 2008
f No berries data for GH; use SMQ data in lieu
g No soil data for MT area; use GH data in lieu
h Includes September 2009 "flow near Star Creek/Christal Creek", and "flow between McQuesten Lake Road/Sandy Creek"
i No berries data for SK; use Elsa (VT) data in lieu
j Includes samples #7, 8, 9, 10, 11 and 12

Table 4.7 Summary of Exposure Point Concentrations for Terrestrial Assessment - Water

COPC	Water Exposure Point Concentration (mg/L)					
	GH	MT	VT	SK	SMQ	UKHM
Antimony	5.1×10^{-4}	1.6×10^{-3}	9.7×10^{-4}	8.5×10^{-4}	2.9×10^{-3}	8.2×10^{-4}
Arsenic	1.2×10^{-2}	1.5×10^{-2}	5.3×10^{-3}	3.4×10^{-3}	8.8×10^{-3}	7.9×10^{-3}
Barium	6.1×10^{-2}	7.8×10^{-2}	5.9×10^{-2}	7.0×10^{-2}	8.2×10^{-2}	6.6×10^{-2}
Cadmium	2.5×10^{-4}	2.6×10^{-3}	8.4×10^{-3}	5.0×10^{-4}	7.9×10^{-4}	4.3×10^{-3}
Chromium	2.5×10^{-3}	1.8×10^{-3}	2.3×10^{-3}	2.0×10^{-3}	9.0×10^{-4}	1.3×10^{-3}
Cobalt	1.9×10^{-3}	1.4×10^{-3}	1.3×10^{-3}	4.8×10^{-4}	1.9×10^{-3}	1.5×10^{-3}
Copper	7.8×10^{-3}	5.2×10^{-3}	6.0×10^{-3}	4.2×10^{-3}	5.2×10^{-3}	4.1×10^{-3}
Lead	3.0×10^{-2}	2.2×10^{-2}	1.4×10^{-2}	1.4×10^{-2}	9.4×10^{-2}	1.1×10^{-2}
Manganese	0.15	0.96	0.84	7.3×10^{-2}	0.45	1.0
Mercury	1.0×10^{-5} (a)	1.0×10^{-5} (a)	1.0×10^{-4} (a)	1.0×10^{-4} (c)	2.0×10^{-5} (a)	8.9×10^{-5}
Molybdenum	5.3×10^{-4}	6.2×10^{-4}	4.6×10^{-4}	7.1×10^{-4}	6.9×10^{-4}	5.8×10^{-4}
Nickel	3.3×10^{-3}	6.4×10^{-3}	5.2×10^{-3}	2.6×10^{-3}	1.1×10^{-2}	9.5×10^{-3}
Selenium	6.8×10^{-4}	1.1×10^{-3}	7.2×10^{-4}	5.1×10^{-4}	4.6×10^{-4}	6.9×10^{-4}
Silver	5.2×10^{-4}	7.3×10^{-4}	2.4×10^{-4}	1.0×10^{-3} (b)	1.2×10^{-3}	3.1×10^{-4}
Strontium	0.10	0.33	0.27	0.18	0.21	0.26
Thallium	3.6×10^{-5}	3.2×10^{-5}	5.0×10^{-5}	5.2×10^{-5}	3.3×10^{-5}	3.0×10^{-5}
Uranium	1.3×10^{-3}	4.5×10^{-3}	3.3×10^{-3}	1.3×10^{-3}	1.1×10^{-3}	2.4×10^{-3}
Vanadium	3.3×10^{-3}	2.5×10^{-3}	3.5×10^{-3}	2.2×10^{-3}	7.6×10^{-4}	1.6×10^{-3}
Zinc	7.2×10^{-2}	0.65	0.97	2.6×10^{-2}	8.9×10^{-2}	1.3
Zirconium	8.8×10^{-4}	8.0×10^{-4}	8.4×10^{-4}	5.0×10^{-4} (b)	5.6×10^{-4}	6.3×10^{-4}

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

a Maximum (N<10)
b Maximum (95% UCLM > maximum)
c No mercury data for SK for 2006 onwards; use VT data in lieu

Table 4.8 Summary of Exposure Point Concentrations for Terrestrial Assessment - Sediment

COPC	Sediment Exposure Point Concentration (mg/kg dw)					
	GH	MT [(a)]	VT [(c)]	SK [(d)]	SMQ	UKHM
Antimony	9.8	97	-	0.04	86	33
Arsenic	351	1750	-	0.11	255	228
Barium	152	297	-	4.2	311	222
Cadmium	20	177	-	2.1	41	34
Chromium	26	19	-	0.06	15	16
Cobalt	10.5	56	-	2.4	17	19
Copper	40	88	-	42	145	49
Lead	408	4450	-	3.7	2931	1544
Manganese	1492	48100	-	73	11151	7552
Mercury	0.24 [(a)]	0.11	-	0.10	0.47	0.22
Molybdenum	3.3	2.5	-	0.64	1.5	1.9
Nickel	31	108	-	4.9	58	50
Selenium	2.5 [(b)]	3.1	-	0.001	4.8	2.6
Silver	10.0	13	-	1.1	13	41
Strontium	17	34	-	178	31	31
Thallium	0.06 [(a)]	0.24	-	0.08	0.42	0.18
Uranium	0.91 [(a)]	7.6	-	0.06	1.5 [(a)]	60
Vanadium	25	32	-	0.11	25	24
Zinc	1084	15200	-	13	1861	2166
Zirconium	2.6	2.5	-	0.50	2.5	2.3

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

a Maximum (N<10)
b Maximum (95% UCLM > maximum)
c Sediment pathway not evaluated for VT location
d Measured sediment data not available; water-to-sediment transfer factors used to estimate concentrations (see Section 4.3.1)

Table 4.9 Summary of Exposure Point Concentrations for Terrestrial Assessment - Fish

COPC	Fish Exposure Point Concentration (mg/kg ww)					
	GH	MT	VT [c]	SK [d]	SMQ	UKHM
Antimony	0.02	0.10	-	0.03	0.25	0.07
Arsenic	0.71	1.7	-	0.13	0.88	0.83
Barium	2.8	1.9	-	0.63	2.6 [b]	2.1
Cadmium	0.22	0.56	-	0.08	0.43	0.36
Chromium	7.8 [b]	0.53	-	0.08	1.3	0.82
Cobalt	0.14	0.07	-	0.10	0.08	0.16
Copper	1.0	0.96	-	0.52	1.1	1.1
Lead	0.49	7.1	-	0.44	9.7	4.2
Manganese	11	49	-	3.1	52	33
Mercury [d]	0.06	0.06	-	0.61	0.12	0.54
Molybdenum	1.0 [b]	0.07	-	0.001	0.17	0.11
Nickel	5.3 [b]	0.34	-	0.05	0.65	0.86
Selenium	2.6	1.1	-	0.61	0.89	1.5
Silver	0.02 [a]	0.03 [a]	-	0.11	0.01 [a]	0.03 [a]
Strontium	8.7	4.1	-	3.7	10.8	10.8
Thallium	0.01 [b]	0.01 [b]	-	0.05	0.02 [b]	0.01
Uranium	0.01	0.02	-	0.001	0.004	0.01
Vanadium	0.25	0.20	-	0.21	0.16	0.15
Zinc	37	57	-	6.5	59	56
Zirconium [d]	0.02	0.02	-	0.01	0.01	0.01

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL; fish tissue and whole fish samples

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

a Maximum (N<10)
b Maximum (95% UCLM > maximum)
c Fish assumed to not be present in VT water bodies
d Measured fish data not available; water-to-fish transfer factors used to estimate concentrations (see Section 4.3.1)

Table 4.10 Summary of Exposure Point Concentrations for Terrestrial Assessment - Aquatic Vegetation

COPC	Aquatic Vegetation Exposure Point Concentration (mg/kg ww) [(a)]					
	GH	MT	VT [(b)]	SK	SMQ	UKHM
Antimony	0.51	1.6	-	0.85	2.9	0.82
Arsenic	2.4	2.9	-	0.68	1.8	1.6
Barium	30	39	-	35	41	33
Cadmium	0.19	2.0	-	0.38	0.60	3.2
Chromium	0.0003	0.0002	-	0.0002	0.0001	0.0002
Cobalt	2.2	1.7	-	0.57	2.3	1.8
Copper	7.8	5.2	-	4.2	5.2	4.1
Lead	4.6	3.3	-	2.1	14	1.7
Manganese	25	163	-	12	77	172
Mercury	0.005	0.005	-	0.05	0.01	0.05
Molybdenum	0.53	0.62	-	0.71	0.69	0.58
Nickel	0.17	0.32	-	0.13	0.54	0.47
Selenium	0.04	0.07	-	0.03	0.03	0.04
Silver	0.10	0.15	-	0.21	0.24	0.06
Strontium	27	86	-	46	54	68
Thallium	$3.6x10^{-5}$	$3.2x10^{-5}$	-	$5.2x10^{-5}$	$3.3x10^{-5}$	$3.0x10^{-5}$
Uranium	0.30	1.0	-	0.29	0.25	0.55
Vanadium	6.6	5.1	-	4.4	1.5	3.2
Zinc	40	355	-	14	49	695
Zirconium	$2.6x10^{-6}$	$2.4x10^{-6}$	-	$1.5x10^{-6}$	$1.7x10^{-6}$	$1.9x10^{-6}$

Notes:

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

a Measured aquatic vegetation data not available; water-to-aquatic vegetation transfer factors used to estimate concentrations (see Section 4.3.1)

b No receptors ingesting aquatic vegetation evaluated in the VT area

Table 4.11 Summary of Exposure Point Concentrations for Terrestrial Assessment - Soil

COPC	Soil Exposure Point Concentration (mg/kg dw)					
	GH	MT [(a)]	VT	SK	SMQ	UKHM
Antimony	1.6	1.6	39	2.7	18	22
Arsenic	19	19	311	27	98	177
Barium	569	569	601	493	211	434
Cadmium	1.9	1.9	33	0.98	14	20
Chromium	15	15	15	12	16	14
Cobalt	6.8	6.8	25	14	30	19
Copper	27	27	58	37	34	44
Lead	52	52	2274	50	312	1173
Manganese	586	586	13151	2954	2486	7355
Mercury	0.08	0.08	0.23	0.06	0.05	0.14
Molybdenum	1.3	1.3	2.5	1.7	1.1	1.8
Nickel	20	20	29	24	112	42
Selenium	1.1	1.1	1.3	1.4	1.6	1.2
Silver	2.1	2.1	16.9	1.2	7.2	9.7
Strontium	54	54	57	73	42	49
Thallium	0.06	0.06	0.67	0.10	0.07	0.37
Uranium	No data					
Vanadium	23	23	27	19	23	21
Zinc	118	118	2427	92	1065	1492
Zirconium	2.8	2.8	2.6	2.6	2.1	2.7

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL
GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area
a No Mackeno Tailings soil data; use GH in lieu

Table 4.12 Summary of Exposure Point Concentrations for Terrestrial Assessment - Forage

COPC	Forage Exposure Point Concentration (mg/kg ww)					
	GH	MT [(a)]	VT	SK	SMQ	UKHM
Antimony	0.02 [(b)]	0.30	0.33	0.02	0.02	0.19
Arsenic	0.02 [(b)]	1.3	0.84	0.02	0.02	0.67
Barium	9.4	21	20	30	36	20
Cadmium	0.003 [(b)]	0.70	0.23	0.008	0.004	0.14
Chromium	0.02 [(b)]	0.15	0.19	0.41	0.10	0.17
Cobalt	0.02 [(b)]	0.13	0.02 [(b)]	0.02	0.02	0.02
Copper	0.02 [(b)]	2.7	2.1	1.6	1.4	1.7
Lead	0.03	5.9	16	0.25	0.06	7.1
Manganese	108	507	128	149	143	151
Mercury	0.002 [(b)]	0.003	0.002	0.003	0.002	0.002
Molybdenum	0.02 [(b)]	0.03	0.02	0.05	0.03	0.02
Nickel	0.11	0.98	0.20	0.51	0.18	0.26
Selenium	0.03 [(b)]	0.08	0.04	0.02	0.04	0.04
Silver	0.002 [(b)]	0.17	0.19	0.01	0.002	0.10
Strontium	1.5	2.1	3.8	3.6	2.2	3.5
Thallium	0.01	0.04	0.04	0.74	0.01	0.17
Uranium	0.006 [(b)]	0.01	0.008	0.007	0.007	0.008
Vanadium	0.08 [(b)]	0.13	0.24	0.30 [(b)]	0.09	0.21
Zinc	3.2	26	21	14	13	19
Zirconium	0.45 [(b)]	0.76	0.66	0.45 [(a)]	0.56	0.59

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL
Values converted from dw to ww basis using reported sample moisture content or typical value of 70%

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

a Maximum (N<10)
b Maximum (95% UCLM > maximum)

Table 4.13 Summary of Exposure Point Concentrations for Terrestrial Assessment - Browse

COPC	Browse Exposure Point Concentration (mg/kg ww)					
	GH	MT [(a)]	VT	SK	SMQ	UKHM
Antimony	0.02 [(b)]	0.31	0.27	0.02 [(b)]	0.02	0.14
Arsenic	0.02 [(b)]	2.2	1.0	0.03	0.02	0.44
Barium	56	38	4.2	4.7	17	11
Cadmium	0.78	17	4.3	1.0	0.53	1.9
Chromium	0.02	0.10	0.34	0.16	0.07	0.19
Cobalt	0.22	3.5	0.08	0.05	0.21	0.15
Copper	0.34	2.2	1.7	2.7	0.79	1.8
Lead	0.05	6.1	8.3	0.20	0.07	3.8
Manganese	110	242	59	60	155	70
Mercury	0.002 [(b)]	0.002	0.002	0.002 [(b)]	0.002	0.002
Molybdenum	0.03	0.26	0.25	0.18	0.07	0.13
Nickel	0.60	17	0.64	0.41	0.67	0.99
Selenium	0.03 [(b)]	2.0	0.10	0.02	0.06	0.10
Silver	0.002	0.20	0.13	0.01	0.002	0.06
Strontium	11	22	8.7	5.0	6.5	7.3
Thallium	0.003 [(b)]	0.004	0.01	0.01	0.004	0.01
Uranium	0.01 [(b)]	0.01	0.01	0.01	0.01	0.01
Vanadium	0.08 [(b)]	0.11	0.26	0.30 [(b)]	0.08	0.23
Zinc	24	289	167	61	47	119
Zirconium	0.45 [(b)]	0.65	0.55	0.45 [(b)]	0.49	0.51

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL
Values converted from dw to ww basis using reported sample moisture content or typical value of 70%

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

a Maximum (N<10)
b Maximum (95% UCLM > maximum)

Table 4.14 Summary of Exposure Point Concentrations for Terrestrial Assessment - Berries

COPC	Berries Exposure Point Concentration (mg/kg ww)					
	GH (c)	MT (a)	VT (d)	SK	SMQ (a)	UKHM
Antimony	0.01	0.01	0.07	0.07	0.01	0.05
Arsenic	0.01	0.05	0.21	0.21	0.01	0.15
Barium	1.5	0.84	1.1	1.1	1.5	4.0
Cadmium	0.06	0.04	0.05	0.05	0.06	0.05
Chromium	0.03	0.01	0.02	0.02	0.03	0.03
Cobalt	0.01	0.01	0.01	0.01	0.01	0.01
Copper	0.74	0.65	0.82	0.82	0.74	0.77
Lead	0.01	0.13	7.2	7.2	0.01	1.6
Manganese	20	7.7	12	12	20	14
Mercury	0.001	0.001	0.001	0.001	0.001	0.001
Molybdenum	0.05	0.01	0.04	0.04	0.05	0.04
Nickel	0.21	0.04	0.08	0.08	0.21	0.16
Selenium	0.01	0.01	0.01	0.01	0.01	0.02
Silver	0.001	0.001	0.05	0.05	0.001	0.03
Strontium	0.18	0.20	0.32	0.32	0.18	2.2
Thallium	0.001	0.001	0.001	0.001	0.001	0.002
Uranium	0.003	0.003	0.003	0.003	0.003	0.003
Vanadium	0.04	0.03	0.04	0.04	0.04	0.04
Zinc	3.1	2.9	3.7	3.7	3.1	3.4
Zirconium	0.22	0.19	0.22	0.22	0.22	0.25

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL
Values converted from dw to ww basis using reported sample moisture content or typical value of 70%

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

a Maximum (N<10)
b Maximum (95% UCLM > maximum)
c No berries data for GH area; data for SMQ used in lieu (browse and forage data statistically similar)
d No berries data for SK area; data for VT used in lieu due to proximity of two areas

Table 4.15 Summary of Exposure Point Concentrations for Terrestrial Assessment - Moss/Lichen

COPC	Moss/Lichen Exposure Point Concentration (mg/kg ww)
	UKHM [(a)]
Antimony	1.9
Arsenic	7.8
Barium	4.5
Cadmium	0.005
Chromium	0.63
Cobalt	0.37
Copper	0.07
Lead	2.7
Manganese	122
Mercury	143
Molybdenum	0.01
Nickel	0.03
Selenium	0.40
Silver	0.05
Strontium	1.2
Thallium	1.5
Uranium	0.01
Vanadium	0.29
Zinc	0.01
Zirconium	0.15

Notes: Values are 95% UCLM (N≥10); values below MDL converted to ½ MDL
Values converted from dw to ww basis using reported sample moisture content or typical value of 40%
UKHM Entirety of Keno Hill area
a Moss/ lichen only an exposure pathway for the caribou, which is evaluated site-wide

4.2.3 Human Health Assessment

For the human health assessment, exposure point concentrations were developed for both the Galena Hill and South McQuesten areas. The relevant exposure media for human receptors for which exposure point concentrations were developed are water, soil, medicinal plants (Labrador tea), berries, and fish. The concentrations for soil and berries were the same as those presented for the terrestrial assessment (Table 4.11 and Table 4.14), while the concentrations for water and fish were modified to more accurately reflect human exposure. Water monitoring stations KV-48, KV-49, KV-50 and KV-51 were not included in the data set to develop concentrations for the Galena Hill area since these represent small water courses from which humans would be unlikely to obtain drinking water. Measurements of metals in fish tissue are more relevant to human consumption than are whole fish measurements and therefore fish tissue measurements were used for the human health assessment when available. In general, data from 2000 and onwards were used. However, for chromium, the measurements from 2008 were much higher than the values measured in 2006 (i.e., 1.38 and 2.5 mg/kg ww versus a range of <0.1 to 0.13 mg/kg ww). As such, the 2008 data were removed from the data set for chromium. For the Galena Hill area, five remaining tissue measurements are available for fish sampled post-2000 and therefore the maximum values were used in the human health assessment. For the South McQuesten area, only one fish flesh sample was available (from 2008) and therefore these data were used in the assessment. For chromium, however, this 2008 value was removed from the data set and thus whole fish tissue measurements were used. Labrador tea data were used to estimate intake from medicinal plants. As discussed in Section 3.2.3.2, a sensitivity analysis was conducted on the medicinal plant intake using willow and birch data in lieu of Labrador tea data (see Section 6.3).

The data used to derive concentrations for the human health assessment are summarized in Table 4.16, while the derived values are provided in Table 4.17. Exposure from consumption of game (beaver, caribou, grouse, hare, marmot, sheep and waterfowl) was evaluated using estimated concentrations of COPC in flesh using transfer factors from relevant intake pathways for each species (see Section 4.3.1). Waterfowl were only evaluated for exposure at the Mackeno Tailings area since this is the only large waterbody and therefore humans were assumed to obtain waterfowl from this location for both the South McQuesten and Galena Hill areas.

Table 4.16 Data Used to Develop Exposure Point Concentrations for Human Health Assessment

Exposure Medium	GH	SMQ
Water	KV-38, KV-41	KV-3, KV-4, KV-9
Fish Flesh	LCD [(a)]	KV-9 [(b)]
Soil	GH data	SMQ data
Berries	SMQ data [(c)]	SMQ data
Medicinal Plants [(d)]	GH data	SMQ data
Caribou	Calculated - UKHM	Calculated - UKHM
Hare	Calculated - GH	Calculated - SMQ
Moose	Calculated - UKHM	Calculated - UKHM
Marmot	Calculated - GH	Calculated - SMQ
Sheep	Calculated - GH	Calculated - SMQ
Beaver	Calculated - GH	Calculated - SMQ
Grouse	Calculated - GH	Calculated - SMQ
Waterfowl	Calculated - MT	Calculated - MT

Notes:

GH	Galena Hill	a	One chromium value from 2008 removed
SMQ	South McQuesten	b	Whole fish data for chromium due to lack of other data
UKHM	Entirety of Keno Hill area	c	No berries data for GH; use SMQ data in lieu
MT	Mackeno Tailings	d	Labrador tea

Table 4.17 Summary of Exposure Point Concentrations for Human Health Assessment

COPC	Water (mg/L)		Soil (mg/kg dw)		Medicinal Plants (mg/kg ww)		Berries (mg/kg ww)	Fish (mg/kg ww)	
	GH	SMQ	GH	SMQ	GH	SMQ	GH/SMQ (a,c)	GH (a)	SMQ (a)
Antimony	6.5×10^{-4}	2.9×10^{-3}	1.6	18	0.02 (b)	0.02	0.01	0.01	0.01
Arsenic	1.6×10^{-2}	8.8×10^{-3}	19	98	0.02 (b)	0.02	0.01	0.43	0.19
Barium	7.1×10^{-2}	8.2×10^{-2}	569	211	9.4	36	1.5	2.7	0.41
Cadmium	2.3×10^{-4}	7.9×10^{-4}	1.9	14	0.003 (b)	0.004	0.06	0.20	0.32
Chromium	3.3×10^{-3}	9.0×10^{-4}	15	16	0.02 (b)	0.10	0.03	0.13	0.16 (b)
Cobalt	2.3×10^{-3}	1.9×10^{-3}	6.8	30	0.02 (b)	0.02	0.01	0.16	0.09
Copper	1.1×10^{-2}	5.2×10^{-3}	27	34	0.02 (b)	1.4	0.74	0.83	0.50
Lead	4.7×10^{-2}	9.4×10^{-2}	52	312	0.03	0.06	0.01	0.41	0.68
Manganese	8.0×10^{-2} (a)	0.45	586	2486	108	143	20	8.9	11
Mercury	1.0×10^{-5}	2.0×10^{-5} (a)	0.08	0.05	0.002 (b)	0.002	0.001	0.06 (d)	0.12 (d)
Molybdenum	5.6×10^{-4}	6.9×10^{-4}	1.3	1.1	0.02 (b)	0.03	0.05	0.17	0.32
Nickel	5.0×10^{-3}	1.1×10^{-2}	20	112	0.11	0.18	0.21	0.93	1.7
Selenium	6.6×10^{-4}	4.6×10^{-4}	1.1	1.6	0.03 (b)	0.04	0.01	3.0	0.44
Silver	7.9×10^{-4}	1.2×10^{-3}	2.1	7.2	0.002 (b)	0.002	0.001	0.01	0.01
Strontium	8.7×10^{-2}	0.21	54	42	1.5	2.2	0.18	12	3.5
Thallium	4.3×10^{-5}	3.3×10^{-5}	0.06	0.07	0.01	0.01	0.001	0.005	0.02
Uranium	6.3×10^{-4}	1.1×10^{-3}	ND	ND	0.006 (b)	0.007	0.003	0.007	0.001
Vanadium	4.8×10^{-3}	7.6×10^{-4}	23	23	0.08 (b)	0.09	0.04	0.14	0.05
Zinc	3.7×10^{-2}	8.9×10^{-2}	118	1065	3.2	13	3.1	32	52

Notes: Values are 95% UCLM (N≥10) unless otherwise specified; values below MDL converted to ½ MDL
Values for berries and medicinal plants converted from dw to ww basis using reported sample moisture content or typical value of 70%

GH Galena Hill
SMQ South McQuesten

a Maximum (N<10)
b Maximum (95% UCLM > maximum
c No berries data for GH; use SMQ data in lieu
d Measured fish data not available; water-to-fish transfer factors used to estimate concentrations (see Section4.3)

4.3 EXPOSURE EQUATIONS

The methodology for estimating total exposure to ecological and human receptors is discussed in the following sections. Sample calculations are provided in Appendix D.

4.3.1 Ecological Assessment

A quantitative estimate of the exposure was conducted for each of the ecological receptors. For the aquatic assessment, the toxicity to aquatic receptors (i.e., aquatic receptors (plants, fish, zooplankton, phytoplankton, benthic invertebrates) is based on measured water and sediment concentrations. An examination of the intake for these receptors is therefore not necessary and the following section pertains to the terrestrial assessment only.

Intakes for the selected ecological receptors were estimated. In essence, the total intake of the COPC for the selected receptors is equal to the sum of COPC intake from all the appropriate pathways including the ingestion of sediment or soil, aquatic vegetation, benthic organisms, fish, terrestrial vegetation, and other mammalian receptors (e.g., hare, waterfowl, etc.). When calculating the intake via the oral route of exposure, it is customary to take into account the food, water and soil pathways. As there was insufficient information to derive site-specific bioavailability/bioaccessibility factors, it was assumed that all the COPC were 100% available from all sources. This is a highly conservative assumption as the reality is that the bioaccessibility of COPC from soil/sediment is generally less than 100%. Equation 4-1 was used to calculate each of the intake routes as follows:

$$I_n = C_n \times IR_n \times f_{loc} \times CF \tag{4-1}$$

Where:

I_n	=	Intake of COPC via "n" exposure pathway [mg/d]
C_n	=	COPC concentration in "n" medium [mg/kg] {Table 4.7 to Table 4.15}
IR_n	=	Intake rate of "n" by the receptor [g/d] {Figure 3.3 to Figure 3.6}
f_{loc}	=	Fraction of time at site [-] {Table 3.2}
CF	=	Conversion factor 1.0×10^{-3} [kg/g]

In order to compare the total COPC intake to the toxicological reference value (which has the units of mg/kg-d), the total intake was divided by the body weight of the ecological receptor.

The exposure point concentrations for water, sediment, fish, aquatic vegetation, soil, and terrestrial vegetation (browse, forage, berries, lichen/moss) as provided in Table 4.7 through to Table 4.15 were used directly in the estimation of intakes by the ecological receptors. These calculations will result in the reasonable maximum average exposure scenario for the evaluated ecological receptors on the site.

When measured data were not available for COPC, transfer factors (TFs) were used to estimate concentrations. The TFs used in the assessment to estimate these concentrations in aquatic vegetation, sediment and fish are presented in Table 4.18. The TFs in Table 4.18 were applied as shown in Equation 4-2 for fish and benthic invertebrates.

$$C_{fish/benthic} = C_{water} \times TF_{water-to-fish/benthic} \qquad (4\text{-}2)$$

Where:

$C_{fish/benthic}$ = COPC concentration in fish or benthic organisms [mg/(kg ww)]
C_{water} = COPC concentration in surface water [mg/L] {Table 4.7}
$TF_{water\text{-}to\text{-}fish/benthic}$ = water-to-fish or benthic transfer factor [L/(kg ww)] {Table 4.18}

For fish, site-specific water-to-fish TFs were used when possible. These TFs were developed from paired measured (i.e., above the MDL) values of COPC in water and fish tissue (i.e., obtained from the same approximate location on the same or similar dates). When sufficient data were available to calculate more than one TF for a COPC, then the average of the values was selected for use in the assessment. If no site-specific TF could be developed, then literature TFs were selected for use and were generally from the International Atomic Energy Agency (IAEA 2010) or the Canadian Standards Association (CSA 2008). In general, the site-specific water-to-fish TFs were similar to values from literature; however, the site-specific TF for zinc was 250 L/(kg ww) in comparison to the literature value from the IAEA (2010) of 3,400 L/(kg ww). The site-specific value was used in the assessment, but a sensitivity analysis was conducted using the IAEA value (see Section 6.3).

For a number of the ecological receptors, ingestion of other organisms (i.e., benthic invertebrates, fish, hares, caribou, moose, spruce grouse, and/or waterfowl) needs to be considered. Smaller organisms such as benthic invertebrates and fish are exposed to COPC through sediment or surface water from the site prior to ingestion by the receptor organism.

More complex organisms such as the hare, caribou, moose, spruce grouse and waterfowl are exposed through multiple pathways before being ingested by other mammals. To calculate the amount of COPC ingested through these food sources, the rate of uptake of COPC by each of these ingested mammals was first calculated using Equation 4-1. Transfer factors from literature for beef or poultry were scaled allometrically for each ingested mammal using their respective body weights and were then applied as shown in Equation 4-3 to calculate the concentration of COPC in the flesh of each ingested mammal. The TFs are shown in Table 4.19 and Table 4.20.

$$C_{flesh} = I_{total} \times TF_{flesh} \qquad (4\text{-}3)$$

Where:

C_{flesh} = COPC concentration in flesh of ingested mammal [mg/(kg ww)]
I_{total} = Intake of COPC via all pathways for ingested mammal [mg/d]
TF_{flesh} = Feed-to-flesh transfer factor [d/(kg ww)] {Table 4.19 and Table 4.20}

Table 4.18 Water-to-Fish, Benthic, Sediment and Aquatic Vegetation Transfer Factors

COPC	Water to Sediment (L/kg dw)		Water to Fish (L/kg ww)		Water to Benthic (L/kg ww)		Water to Aq. Veg. (L/kg ww)	
	TF	Reference	TF	Reference	TF	Reference	TF	Reference
Antimony	45	U.S. EPA 1998	37	IAEA 2010	10	NRCC 1983	1000	Staven 2003
Arsenic	31	U.S. EPA 1998	38	Site-specific average	1700	U.S. EPA 1979, COGEMA 1997	200	NTIS 1988, CSA 1987
Barium	60	Bechtel Jacobs 1998	9.1	Site-specific average	200	NRCC 1983	500	NRCC 1983
Cadmium	4300	U.S. EPA 1998	167	Site-specific average	100	IAEA 2010	760	U.S. EPA 2001
Chromium	30	Bechtel Jacobs 1998	40	IAEA 2010	20	NRCC 1983	0.12	Bird and Schwartz 1996
Cobalt	5000	IAEA 1994, Bechtel Jacobs 1998	201	Site-specific average	22	IAEA 2010	1200	Bird and Schwartz 1996
Copper	10000	IAEA 1994, Bechtel Jacobs 1998	126	Site-specific average	42	IAEA 2010	1000	ORNL 1976
Lead	270	Bechtel Jacobs 1998	32	Site-specific average	22	IAEA 2010	1800	IAEA 2010
Manganese	1000	IAEA 1994	42	Site-specific average	0.075	Bird and Schwartz 1996	170	Bird and Schwartz 1996
Mercury	1000	U.S. EPA 1998	6100	IAEA 2010	750	IAEA 2010	530	Bird and Schwartz 1996
Molybdenum	900	Sheppard and Thibault 1990, for clay soil with a factor of 10	1.9	IAEA 2010	0.45	IAEA 2010	1000	ORNL 1976, NTIS 1989
Nickel	1900	U.S. EPA 1998	21	IAEA 2010	100	U.S. EPA 1979	50	ORNL 1976
Selenium	2.2	U.S. EPA 1998	1184	Site-specific average	570	IAEA 2010	63	Santschi and Honeyman 1989
Silver	1100	U.S. EPA 1998	110	IAEA 2010	770	NRCC 1983	200	NRCC 1983
Strontium	1000	IAEA 1994	21	Site-specific average	270	IAEA 2010	260	Bird and Schwartz 1996
Thallium	1500	Baes *et al.* 1984	900	IAEA 2010	5000	Napier *et al.* 1988	1	Napier *et al.* 1988
Uranium	50	Bechtel Jacobs 1998	0.86	IAEA 2010	170	IAEA 2010	230	IAEA 2010
Vanadium	50	U.S. EPA 1998	97	IAEA 2010	380	IAEA 2010	2000	U.S. NRC 1977
Zinc	500	IAEA 1994, Bechtel Jacobs 1998	250	Site-specific average	92	IAEA 2010	550	NTIS 1988, CSA1987
Zirconium	1000	IAEA 1994, Bechtel Jacobs 1998	22	IAEA 2010	50	Napier *et al.* 1988	0.003	No data; assumed same as literature soil-to-vegetation

Table 4.19 Feed-to-Flesh Transfer Factors for Caribou, Hare and Moose

COPC	Non-Scaled Feed-to-Flesh (mammal) (d/kg ww)	Reference	Scaled Feed-to-Flesh (d/kg ww)		
			Caribou	Hare	Moose
Antimony	1.2×10^{-3}	IAEA 2010	3.7×10^{-3}	1.1×10^{-1}	1.2×10^{-3}
Arsenic	2.0×10^{-3}	IAEA 1994, NCRP 1996, Baes *et al*. 1984, U.S. EPA 1998, CSA 1987	6.1×10^{-3}	1.9×10^{-1}	2.0×10^{-3}
Barium	1.4×10^{-4}	IAEA 2010	4.3×10^{-4}	1.3×10^{-2}	1.4×10^{-4}
Cadmium	5.2×10^{-4}	IAEA 1994, NCRP 1996, Baes *et al*. 1984, U.S. EPA 1998, CSA 1987	1.6×10^{-3}	4.9×10^{-2}	5.2×10^{-4}
Chromium	5.5×10^{-3}	IAEA 1994, NCRP 1996, Baes *et al*. 1984, U.S. EPA 1998, CSA 1987	1.7×10^{-2}	5.2×10^{-1}	5.5×10^{-3}
Cobalt	4.3×10^{-4}	IAEA 2010	1.3×10^{-3}	4.1×10^{-2}	4.3×10^{-4}
Copper	9.0×10^{-3}	IAEA 1994	2.8×10^{-2}	8.5×10^{-1}	9.0×10^{-3}
Iron	1.4×10^{-2}	IAEA 2010	4.3×10^{-2}	1.3	1.4×10^{-2}
Lead	7.0×10^{-4}	IAEA 2010	2.1×10^{-3}	6.6×10^{-2}	7.0×10^{-4}
Manganese	6.0×10^{-4}	IAEA 2010	1.8×10^{-3}	5.7×10^{-2}	6.0×10^{-4}
Mercury	1.0×10^{-2}	CSA 2008	3.1×10^{-2}	9.4×10^{-1}	1.0×10^{-2}
Molybdenum	1.0×10^{-3}	IAEA 2010	3.1×10^{-3}	9.4×10^{-2}	1.0×10^{-3}
Nickel	5.0×10^{-3}	CSA 2008	1.5×10^{-2}	4.7×10^{-1}	5.0×10^{-3}
Selenium	1.0×10^{-1}	CSA 2008	3.1×10^{-1}	9.4	1.0×10^{-1}
Silver	2.1×10^{-3}	CSA 2008	6.4×10^{-3}	2.0×10^{-1}	2.1×10^{-3}
Strontium	1.3×10^{-3}	IAEA 2010	4.0×10^{-3}	1.2×10^{-1}	1.3×10^{-3}
Thallium	3.0×10^{-2}	NCRP 1996, Baes *et al*. 1984	9.2×10^{-2}	2.8	3.0×10^{-2}
Uranium	3.9×10^{-4}	IAEA 2010	1.2×10^{-3}	3.7×10^{-2}	3.9×10^{-4}
Vanadium	2.5×10^{-3}	Baes *et al*. 1984	7.7×10^{-3}	2.4×10^{-1}	2.5×10^{-3}
Zinc	1.6×10^{-1}	IAEA 2010	4.9×10^{-1}	1.5×10^{1}	1.6×10^{-1}
Zirconium	1.2×10^{-6}	IAEA 2010	3.7×10^{-6}	1.1×10^{-4}	1.2×10^{-6}

Table 4.20 Feed-to-Flesh Transfer Factors for Waterfowl and Spruce Grouse

COPC	Non-Scaled Feed-to-Flesh (bird) (d/kg ww)	Reference	Scaled Feed-to-Flesh (d/kg ww)			
			Mallard	Merganser	Scaup	Spruce Grouse
Antimony	$5.0x10^{-1}$	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987	$7.9x10^{-1}$	$8.4x10^{-1}$	$9.8x10^{-1}$	1.2
Arsenic	1.0	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987	1.6	1.7	2.0	2.4
Barium	$1.9x10^{-2}$	IAEA 2010	$3.0x10^{-2}$	$3.2x10^{-2}$	$3.7x10^{-2}$	$4.6x10^{-2}$
Cadmium	1.7	IAEA 2010	2.7	2.9	3.3	4.1
Chromium	$9.2x10^{-1}$	CSA 2008	1.5	1.5	1.8	2.2
Cobalt	$9.7x10^{-1}$	IAEA 2010	1.5	1.6	1.9	2.3
Copper	$5.0x10^{-1}$	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987	$7.9x10^{-1}$	$8.4x10^{-1}$	$9.8x10^{-1}$	1.2
Iron	1.4	CSA 2008	2.2	2.4	2.7	3.4
Lead	$2.0x10^{-1}$	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987	$3.2x10^{-1}$	$3.4x10^{-1}$	$3.9x10^{-1}$	$4.8x10^{-1}$
Manganese	$1.9x10^{-3}$	IAEA 2010	$3.0x10^{-3}$	$3.2x10^{-3}$	$3.7x10^{-3}$	$4.6x10^{-3}$
Mercury	$2.7x10^{-2}$	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987	$4.3x10^{-2}$	$4.5x10^{-2}$	$5.3x10^{-2}$	$6.5x10^{-2}$
Molybdenum	$1.8x10^{-1}$	IAEA 2010	$2.9x10^{-1}$	$3.0x10^{-1}$	$3.5x10^{-1}$	$4.3x10^{-1}$
Nickel	$3.1x10^{-1}$	CSA 2008	$4.9x10^{-1}$	$5.2x10^{-1}$	$6.1x10^{-1}$	$7.5x10^{-1}$
Selenium	9.7	IAEA 2010	$1.5x10^{1}$	$1.6x10^{1}$	$1.9x10^{1}$	$2.3x10^{1}$
Silver	$4.0x10^{-1}$	CSA 2008	$6.3x10^{-1}$	$6.7x10^{-1}$	$7.8x10^{-1}$	$9.6x10^{-1}$
Strontium	$2.3x10^{-2}$	IAEA 2010	$3.7x10^{-2}$	$3.9x10^{-2}$	$4.5x10^{-2}$	$5.5x10^{-2}$
Thallium	$1.5x10^{1}$	No value; assume 500 times the value for mammals	$2.4x10^{1}$	$2.5x10^{1}$	$2.9x10^{1}$	$3.6x10^{1}$
Uranium	$7.5x10^{-1}$	IAEA 2010	1.2	1.3	1.5	1.8
Vanadium	1.3	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987	2.1	2.2	2.5	3.1
Zinc	$4.7x10^{-1}$	IAEA 2010	$7.5x10^{-1}$	$7.9x10^{-1}$	$9.2x10^{-1}$	1.1
Zirconium	$6.0x10^{-5}$	IAEA 2010	$9.5x10^{-5}$	$1.0x10^{-4}$	$1.2x10^{-4}$	$1.4x10^{-4}$

4.3.2 Human Health Assessment

The exposure assessment considered the inhalation, dermal and ingestion pathways using the receptor characteristics provided in Section 3.2.3. The exposure equations used in the assessment were obtained from Health Canada (2009b) and are provided below.

4.3.2.1 Inhalation Pathway

Inhalation intake by human receptors was calculated using Equation 4-4 for the air pathway:

$$I_a = \frac{C_{air} \times IR_a \times AF_{inh} \times F_{site} \times ED}{BW \times LE} \qquad (4\text{-}4)$$

Where:

I_a	=	Intake of COPC through the inhalation pathway [mg/(kg-d)]
C_{air}	=	Concentration of COPC in air [mg/m^3]
IR_a	=	Inhalation rate [m^3/d]
AF_{inh}	=	Inhalation absorption factor [-] {assumed to be 1}
F_{site}	=	Fraction of time at site [-] {assumed to be 0.025, equivalent to ~200 hr/y}
ED	=	Total years exposed to site [y] {for carcinogenic COPC only}
BW	=	Body weight [kg]
LE	=	Life expectancy [y] {for carcinogenic COPC only}

No volatile COPC are present at the site and therefore exposure through the air inhalation pathway is limited to respirable particulate. COPC concentrations associated with particulate in air are not available for the site and thus concentrations in ambient air (C_{air} in Equation 4-4) were estimated based upon an assumed respirable (≤ 10 µm) particulate concentration of 0.76 µg/m^3 (or 7.6x10^{-10} kg/m^3) as provided by Health Canada (2009b) and the site specific soil concentrations as shown in Equation 4-5.

$$C_{air} = C_{soil} \times P_{air} \qquad (4\text{-}5)$$

Where:

C_{air}	=	Concentration of COPC in air [mg/m^3]
C_{soil}	=	Concentration of COPC in soil [mg/(kg dw)] {Table 4.17}
P_{air}	=	Particulate concentration in air [7.6×10^{-10} kg /m^3]

4.3.2.2 Dermal Pathway

Dermal exposure for human receptors was calculated for soil contact using the following equation:

$$I^{s}_{dermal} = \frac{C_{soil} \times (SA \times SL) \times RAF \times EF \times F_{site} \times ED}{BW \times LE} \tag{4-6}$$

Where:

I^{s}_{dermal} = Intake of COPC in soil through the dermal pathway [mg/(kg-d)]
C_{soil} = Concentration of COPC in soil [mg/(kg dw)] {Table 4.17}
SA = Exposed skin surface area [cm^2]
SL = Soil loading to exposed skin [(kg dw)/(cm^2·event)]
RAF = Dermal absorption factor [-]
EF = Exposure frequency [events/d] {assumed to be 1 event per day on site}
F_{site} = Fraction of time at site [-] {assumed to be 0.125, or 1.5 months per year}
ED = Total years exposed to site [y] {for carcinogenic COPC only}
BW = Body weight [kg]
LE = Life expectancy [y] {for carcinogenic COPC only}

4.3.2.3 Ingestion Pathway

Ingestion intake by human receptors was calculated using Equation 4-7 for the water pathway:

$$I_{wat} = \frac{C_{wat} \times IR_{wat} \times AF_{ing} \times F_{site} \times ED}{BW \times LE} \tag{4-7}$$

Where:

I_{wat} = Intake of COPC through the ingestion of water pathway [mg/(kg-d)]
C_{wat} = Concentration of COPC in water [mg/L] {Table 4.17}
IR_{wat} = Water ingestion rate [L/d]
AF_{ing} = Ingestion absorption factor [-] {assumed to be 1}
F_{site} = Fraction of time at site [-] {assumed to be 0.125, or 1.5 months per year}
ED = Total years exposed to site [y] {for carcinogenic COPC only}
BW = Body weight [kg]
LE = Life expectancy [y] {for carcinogenic COPC only}

Ingestion intake by human receptors was calculated using Equation 4-8 for the soil pathway:

$$I_{soil} = \frac{C_{soil} \times IR_{soil} \times AF_{ing} \times F_{site} \times ED \times CF}{BW \times LE} \tag{4-8}$$

Where:

I_{soil} = Intake of COPC through the ingestion of soil pathway [mg/(kg-d)]
C_{soil} = Concentration of COPC in soil [mg/(kg dw)] {Table 4.17}
IR_{soil} = Soil ingestion rate [(g dw)/d]

AF_{ing} = Ingestion absorption factor [-] {assumed to be 1}
F_{site} = Fraction of time at site [-] {assumed to be 0.125, or 1.5 months per year}
ED = Total years exposed to site [y] {for carcinogenic COPC only}
BW = Body weight [kg]
LE = Life expectancy [y] {for carcinogenic COPC only}
CF = Conversion factor 1.0×10^{-3} [kg/g]

Ingestion intake by human receptors was calculated using Equation 4-9 for the food pathway:

$$I_{foodx} = \frac{C_x \times IR_x \times AF_{ing} \times F_{food} \times ED \times CF}{BW \times LE} \tag{4-9}$$

Where:

I_{foodx} = Intake of COPC through the ingestion of food pathway [mg/(kg-d)], where 'x' is berry, Labrador tea, fish, beaver, caribou, hare, marmot, moose, sheep, spruce grouse or mallard
C_x = Concentration of COPC in 'x' [mg/(kg ww)]
IR_x = Ingestion rate of 'x' [(g ww)/d]
AF_{ing} = Ingestion absorption factor [-] {assumed to be 1}
Ffood = Fraction of time at eating food from site [-] {assumed to be 0.5, or 6 months per year}
ED = Total years exposed to site [y] {for carcinogenic COPC only}
BW = Body weight [kg]
LE = Life expectancy [y] {for carcinogenic COPC only}
CF = Conversion factor 1.0×10^{-3} [kg/g]

As was done for the terrestrial assessment, transfer factors from literature for beef or poultry were scaled for each ingested mammal using their respective body weights in order to calculate the concentration of COPC in the flesh (Equation 4-3). The TFs for the mallard, spruce grouse, caribou, hare and moose were presented in Table 4.19 and Table 4.20, while the TFs for the remaining mammals (beaver, marmot, sheep) are presented in Table 4.21.

Table 4.21 Feed-to-Flesh Transfer Factors for Beaver, Marmot and Sheep

COPC	Non-Scaled Feed-to-Flesh (mammal) (d/kg ww)	Reference	Scaled Feed-to-Flesh (d/kg ww)		
			Beaver	Marmot	Sheep
Antimony	1.2×10^{-3}	IAEA 2010	1.3×10^{-2}	4.7×10^{-2}	6.0×10^{-3}
Arsenic	2.0×10^{-3}	IAEA 1994, NCRP 1996, Baes *et al*. 1984, U.S. EPA 1998, CSA 1987	2.2×10^{-2}	7.9×10^{-2}	1.0×10^{-2}
Barium	1.4×10^{-4}	IAEA 2010	1.6×10^{-3}	5.5×10^{-3}	7.0×10^{-4}
Cadmium	5.2×10^{-4}	IAEA 1994, NCRP 1996, Baes *et al*. 1984, U.S. EPA 1998, CSA 1987	5.8×10^{-3}	2.0×10^{-2}	2.6×10^{-3}
Chromium	5.5×10^{-3}	IAEA 1994, NCRP 1996, Baes *et al*. 1984, U.S. EPA 1998, CSA 1987	6.2×10^{-2}	2.2×10^{-1}	2.8×10^{-2}
Cobalt	4.3×10^{-4}	IAEA 2010	4.8×10^{-3}	1.7×10^{-2}	2.2×10^{-3}
Copper	9.0×10^{-3}	IAEA 1994	1.0×10^{-1}	3.5×10^{-1}	4.5×10^{-2}
Iron	1.4×10^{-2}	IAEA 2010	1.6×10^{-1}	5.5×10^{-1}	7.0×10^{-2}
Lead	7.0×10^{-4}	IAEA 2010	7.8×10^{-3}	2.7×10^{-2}	3.5×10^{-3}
Manganese	6.0×10^{-4}	IAEA 2010	6.7×10^{-3}	2.4×10^{-2}	3.0×10^{-3}
Mercury	1.0×10^{-2}	CSA 2008	1.1×10^{-1}	3.9×10^{-1}	5.0×10^{-2}
Molybdenum	1.0×10^{-3}	IAEA 2010	1.1×10^{-2}	3.9×10^{-2}	5.0×10^{-3}
Nickel	5.0×10^{-3}	CSA 2008	5.6×10^{-2}	2.0×10^{-1}	2.5×10^{-2}
Selenium	1.0×10^{-1}	CSA 2008	1.1	3.9	5.0×10^{-1}
Silver	2.1×10^{-3}	CSA 2008	2.3×10^{-2}	8.2×10^{-2}	1.1×10^{-2}
Strontium	1.3×10^{-3}	IAEA 2010	1.5×10^{-2}	5.1×10^{-2}	6.5×10^{-3}
Thallium	3.0×10^{-2}	NCRP 1996, Baes *et al*. 1984	3.4×10^{-1}	1.2	1.5×10^{-1}
Uranium	3.9×10^{-4}	IAEA 2010	4.4×10^{-3}	1.5×10^{-2}	2.0×10^{-3}
Vanadium	2.5×10^{-3}	Baes *et al*. 1984	2.8×10^{-2}	9.8×10^{-2}	1.3×10^{-2}
Zinc	1.6×10^{-1}	IAEA 2010	1.8	6.3	8.0×10^{-1}
Zirconium	1.2×10^{-6}	IAEA 2010	1.3×10^{-5}	4.7×10^{-5}	6.0×10^{-6}

4.4 INTAKES

The total intake of each COPC by terrestrial and human receptors was calculated using the equations presented in the previous section. The intakes are provided in the following section. As discussed previously, intakes are not calculated for aquatic receptors in the aquatic assessment since potential risks are evaluated by direct comparison of measured concentrations to toxicity values.

4.4.1 Terrestrial Intakes

The total intakes for each terrestrial receptor are presented in Table 4.22. Detailed breakdowns by intake pathway are presented in Appendix B.

4.4.2 Human Intakes

As discussed in Section 3.2.1, it has been assumed that individuals may be present at two different locations (South McQuesten and Galena Hill) while camping at the historic Keno Hill Mine site during hunting and gathering activities. Although individuals may only be present on the site for 1.5 months per year, it has been assumed that individuals would fish, hunt and trap at the site and would subsequently bring food back to their communities for consumption over a six month period. Year-round residents at Keno City will be considered in a subsequent phase.

The intakes for the toddler receptor are presented in Table 4.23 for the South McQuesten area and Table 4.24 for the Galena Hill area. The results for the toddler are presented since the toddler is the most exposed receptor. The intakes for all receptors (toddler, child, teen, adult) are provided in Appendix B. For comparison purposes, the inhalation intakes were converted from units of mg/m^3 to mg/(kg d) using the toddler inhalation rate of 8.31 mg/m^3 and body weight of 16.5 kg. From these tables, it can be seen that ingestion is the dominant pathway for all COPC, while inhalation contributes the least to the toddler's intake.

The breakdowns by pathways for ingestion exposure for receptors at both areas are provided in Table 4.25 and Table 4.26. From these tables it can be seen ingestion of water, fish, beaver and moose contribute the most to the toddler's intake from ingestion. The contributions from the remaining ingestion routes are relatively small and generally comprise less than 5% of the ingestion intake.

It should be noted that this assessment assumes that individuals are present at the location of the reasonable maximum exposure concentration (i.e., maximum or 95% UCLM value) for the entire time on site.

Table 4.22 Calculated Total Intakes for Ecological Receptors

Total Intake (mg/(kg-d))	Mallard	Merganser	Scaup	Beaver				Mink			
	MT	MT	MT	GH	MT	SK	SMQ	GH	MT	SK	SMQ
Antimony	0.12	7.2×10^{-2}	0.35	6.0×10^{-2}	0.34	6.7×10^{-2}	0.40	3.7×10^{-2}	0.25	2.0×10^{-2}	0.26
Arsenic	3.6	1.3	9.5	0.87	3.8	5.6×10^{-2}	0.64	1.6	5.0	0.48	1.4
Barium	2.7	0.45	3.7	6.9	6.5	3.1	5.1	1.3	1.7	0.77	1.8
Cadmium	0.22	0.19	0.67	0.11	1.8	0.11	0.17	0.12	0.57	6.4×10^{-2}	0.20
Chromium	1.8×10^{-2}	8.7×10^{-2}	6.9×10^{-2}	5.2×10^{-2}	4.4×10^{-2}	1.2×10^{-2}	3.5×10^{-2}	1.2	0.12	1.9×10^{-2}	0.22
Cobalt	9.5×10^{-2}	4.5×10^{-2}	0.22	0.21	0.51	5.3×10^{-2}	0.23	7.7×10^{-2}	0.16	3.3×10^{-2}	8.3×10^{-2}
Copper	0.24	0.19	0.40	0.71	0.75	0.62	0.75	0.34	0.42	0.24	0.55
Lead	4.7	3.7	16.0	5.1	12.0	2.0	19.0	1.7	11.0	0.46	9.9
Manganese	43.0	36.0	1.7×10^{2}	13.0	1.3×10^{2}	5.7	40.0	5.1	1.1×10^{2}	0.81	33.0
Mercury	8.9×10^{-4}	8.9×10^{-3}	1.5×10^{-3}	1.0×10^{-3}	8.0×10^{-4}	4.5×10^{-3}	1.9×10^{-3}	9.5×10^{-3}	9.2×10^{-3}	9.0×10^{-2}	1.9×10^{-2}
Molybdenum	2.0×10^{-2}	1.2×10^{-2}	1.7×10^{-2}	5.0×10^{-2}	7.3×10^{-2}	7.0×10^{-2}	6.3×10^{-2}	0.16	2.3×10^{-2}	9.7×10^{-3}	3.5×10^{-2}
Nickel	0.15	0.11	0.46	0.12	1.5	5.1×10^{-2}	0.21	0.84	0.34	3.3×10^{-2}	0.26
Selenium	5.7×10^{-2}	0.16	9.6×10^{-2}	1.1×10^{-2}	0.16	4.4×10^{-3}	1.6×10^{-2}	0.44	0.31	0.15	0.20
Silver	6.3×10^{-2}	1.1×10^{-2}	0.12	2.8×10^{-2}	5.2×10^{-2}	1.9×10^{-2}	4.4×10^{-2}	3.6×10^{-2}	4.6×10^{-2}	3.9×10^{-2}	5.3×10^{-2}
Strontium	0.10	0.63	14.0	3.0	8.5	4.4	4.8	2.2	3.4	2.4	3.3
Thallium	1.4×10^{-2}	8.7×10^{-4}	2.3×10^{-2}	3.5×10^{-4}	8.1×10^{-4}	1.3×10^{-3}	1.2×10^{-3}	1.7×10^{-2}	1.7×10^{-2}	2.9×10^{-2}	1.9×10^{-2}
Uranium	0.10	8.2×10^{-3}	0.15	2.5×10^{-2}	9.7×10^{-2}	2.4×10^{-2}	2.3×10^{-2}	1.5×10^{-2}	5.1×10^{-2}	1.2×10^{-2}	1.4×10^{-2}
Vanadium	0.25	4.8×10^{-2}	0.31	0.57	0.47	0.36	0.17	0.20	0.19	0.11	0.11
Zinc	27.0	17.0	65.0	7.0	80.0	5.9	11.0	11.0	66.0	6.6	20.0
Zirconium	5.4×10^{-3}	4.1×10^{-3}	1.4×10^{-2}	4.0×10^{-2}	5.5×10^{-2}	3.5×10^{-2}	4.3×10^{-2}	9.5×10^{-3}	8.9×10^{-3}	3.2×10^{-3}	7.9×10^{-3}

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

Table 4.22 Calculated Total Intakes for Ecological Receptors (Cont'd)

Total Intake (mg/(kg-d))	Fox					Grouse					Hare				
	GH	MT	VT	SK	SMQ	GH	MT	VT	SK	SMQ	GH	MT	VT	SK	SMQ
Antimony	9.4×10^{-3}	9.7×10^{-3}	3.2×10^{-2}	1.1×10^{-2}	1.9×10^{-2}	1.4×10^{-2}	7.1×10^{-2}	0.32	2.4×10^{-2}	0.13	9.9×10^{-3}	7.2×10^{-2}	0.22	1.4×10^{-2}	7.8×10^{-2}
Arsenic	0.46	0.49	0.74	0.47	0.53	0.13	0.54	2.3	0.20	0.67	8.0×10^{-2}	0.46	1.5	0.12	0.41
Barium	0.36	0.35	0.37	0.31	0.15	14.0	11.0	4.9	4.3	4.7	10.0	8.9	4.6	5.0	6.0
Cadmium	5.7×10^{-2}	0.10	8.9×10^{-2}	5.7×10^{-2}	6.5×10^{-2}	0.16	3.2	1.0	0.20	0.20	0.11	2.2	0.70	0.14	0.13
Chromium	1.6×10^{-2}	1.6×10^{-2}	1.8×10^{-2}	1.6×10^{-2}	1.7×10^{-2}	0.10	0.12	0.17	0.11	0.12	6.4×10^{-2}	8.6×10^{-2}	0.12	0.10	8.1×10^{-2}
Cobalt	1.4×10^{-2}	1.5×10^{-2}	2.5×10^{-2}	1.8×10^{-2}	2.8×10^{-2}	8.8×10^{-2}	0.72	0.19	0.10	0.24	5.7×10^{-2}	0.49	0.11	6.4×10^{-2}	0.15
Copper	3.8×10^{-2}	5.3×10^{-2}	7.3×10^{-2}	6.1×10^{-2}	4.9×10^{-2}	0.28	0.62	0.75	0.80	0.41	0.16	0.61	0.63	0.63	0.35
Lead	0.18	0.18	1.6	0.25	0.34	0.36	1.5	17.0	0.63	2.1	0.22	1.5	12.0	0.25	1.3
Manganese	0.62	0.68	8.0	1.9	1.8	26.0	50.0	1.0×10^{2}	32.0	47.0	25.0	75.0	72.0	32.0	42.0
Mercury	8.9×10^{-5}	9.5×10^{-5}	2.1×10^{-4}	9.0×10^{-5}	7.5×10^{-5}	8.3×10^{-4}	9.6×10^{-4}	1.9×10^{-3}	7.4×10^{-4}	7.1×10^{-4}	6.3×10^{-4}	8.0×10^{-4}	1.3×10^{-3}	6.7×10^{-4}	5.9×10^{-4}
Molybdenum	1.5×10^{-3}	1.2×10^{-3}	2.2×10^{-3}	1.7×10^{-3}	1.4×10^{-3}	1.6×10^{-2}	5.9×10^{-2}	6.5×10^{-2}	4.7×10^{-2}	2.3×10^{-2}	1.0×10^{-2}	4.1×10^{-2}	4.4×10^{-2}	3.4×10^{-2}	1.6×10^{-2}
Nickel	2.4×10^{-2}	6.4×10^{-2}	2.9×10^{-2}	2.5×10^{-2}	8.5×10^{-2}	0.26	3.3	0.32	0.24	0.89	0.17	2.3	0.22	0.19	0.56
Selenium	7.9×10^{-2}	0.18	8.4×10^{-2}	7.9×10^{-2}	8.2×10^{-2}	1.4×10^{-2}	0.38	2.9×10^{-2}	1.5×10^{-2}	2.3×10^{-2}	1.1×10^{-2}	0.26	2.2×10^{-2}	1.1×10^{-2}	1.7×10^{-2}
Silver	3.7×10^{-3}	4.0×10^{-3}	1.3×10^{-2}	3.6×10^{-3}	6.8×10^{-3}	1.5×10^{-2}	5.3×10^{-2}	0.14	1.2×10^{-2}	4.9×10^{-2}	9.1×10^{-3}	4.9×10^{-2}	0.10	7.1×10^{-3}	3.0×10^{-2}
Strontium	6.6×10^{-2}	9.2×10^{-2}	8.2×10^{-2}	8.1×10^{-2}	6.4×10^{-2}	2.5	4.5	2.1	1.5	1.5	1.8	3.2	1.7	1.2	1.2
Thallium	1.6×10^{-2}	1.7×10^{-2}	1.7×10^{-2}	2.3×10^{-2}	1.6×10^{-2}	1.1×10^{-3}	1.3×10^{-3}	6.7×10^{-3}	3.5×10^{-3}	1.3×10^{-3}	1.5×10^{-3}	4.1×10^{-3}	7.6×10^{-3}	6.2×10^{-2}	2.0×10^{-3}
Uranium	5.3×10^{-3}	5.5×10^{-3}	5.4×10^{-3}	5.3×10^{-3}	5.3×10^{-3}	1.3×10^{-3}	2.1×10^{-3}	2.9×10^{-3}	2.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	2.4×10^{-3}	2.7×10^{-3}	2.2×10^{-3}	1.6×10^{-3}
Vanadium	3.4×10^{-2}	3.4×10^{-2}	3.7×10^{-2}	3.2×10^{-2}	3.4×10^{-2}	0.17	0.18	0.24	0.19	0.17	0.11	0.11	0.17	0.14	0.11
Zinc	3.9	26.0	24.0	7.4	9.2	5.4	56.0	48.0	12.0	16	3.8	40.0	33.0	9.4	11.0
Zirconium	3.8×10^{-3}	3.5×10^{-3}	3.7×10^{-3}	3.6×10^{-3}	3.3×10^{-3}	0.11	0.15	0.13	0.11	0.12	0.11	0.16	0.14	0.10	0.12

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

Table 4.22 Calculated Total Intakes for Ecological Receptors (Cont'd)

Total Intake (mg/(kg-d))	Marmot					Sheep					Bear	Caribou	Moose	Wolf
	GH	MT	VT	SK	SMQ	GH	MT	VT	SK	SMQ	UKHM	UKHM	UKHM	UKHM
Antimony	5.6×10^{-3}	5.5×10^{-2}	0.13	8.0×10^{-3}	3.7×10^{-2}	4.3×10^{-3}	3.4×10^{-2}	9.8×10^{-2}	6.3×10^{-3}	3.2×10^{-2}	3.7×10^{-2}	5.1×10^{-2}	1.5×10^{-2}	6.5×10^{-3}
Arsenic	3.7×10^{-2}	0.26	0.71	5.4×10^{-2}	0.18	3.2×10^{-2}	0.17	0.59	4.7×10^{-2}	0.16	0.28	0.27	7.4×10^{-2}	1.1×10^{-1}
Barium	2.7	4.7	4.6	6.1	6.7	1.9	3.1	3.1	4.0	4.2	1.3	0.47	0.54	1.2×10^{-1}
Cadmium	4.0×10^{-3}	0.12	0.10	3.1×10^{-3}	2.7×10^{-2}	3.4×10^{-3}	7.7×10^{-2}	7.9×10^{-2}	2.4×10^{-3}	2.3×10^{-2}	3.9×10^{-2}	3.1×10^{-2}	8.7×10^{-2}	2.1×10^{-2}
Chromium	3.0×10^{-2}	5.3×10^{-2}	6.0×10^{-2}	9.3×10^{-2}	4.6×10^{-2}	2.6×10^{-2}	4.0×10^{-2}	4.4×10^{-2}	6.3×10^{-2}	3.6×10^{-2}	3.6×10^{-2}	1.7×10^{-2}	1.0×10^{-2}	6.7×10^{-3}
Cobalt	1.5×10^{-2}	3.5×10^{-2}	4.9×10^{-2}	2.8×10^{-2}	5.8×10^{-2}	1.3×10^{-2}	2.5×10^{-2}	4.3×10^{-2}	2.4×10^{-2}	5.0×10^{-2}	2.7×10^{-2}	1.5×10^{-2}	1.6×10^{-2}	5.3×10^{-3}
Copper	5.3×10^{-2}	0.53	0.47	0.34	0.30	4.6×10^{-2}	0.34	0.32	0.23	0.20	0.15	8.9×10^{-2}	8.7×10^{-2}	2.7×10^{-2}
Lead	0.10	1.1	7.0	0.14	0.59	8.8×10^{-2}	0.71	5.4	0.11	0.52	1.9	3.1	0.56	3.4×10^{-1}
Manganese	20.0	89.0	46.0	31.0	29.0	12.0	55.0	35.0	21.0	19.0	15.0	8.5	4.8	2.1
Mercury	4.0×10^{-4}	5.8×10^{-4}	7.8×10^{-4}	5.7×10^{-4}	4.2×10^{-4}	2.8×10^{-4}	3.9×10^{-4}	5.9×10^{-4}	3.8×10^{-4}	2.9×10^{-4}	7.6×10^{-3}	3.1×10^{-4}	2.8×10^{-4}	8.8×10^{-5}
Molybdenum	5.0×10^{-3}	6.8×10^{-3}	8.1×10^{-3}	1.1×10^{-2}	7.0×10^{-3}	3.7×10^{-3}	4.8×10^{-3}	6.2×10^{-3}	7.7×10^{-3}	4.8×10^{-3}	6.0×10^{-3}	2.2×10^{-3}	6.9×10^{-3}	6.0×10^{-4}
Nickel	5.6×10^{-2}	0.21	8.9×10^{-2}	0.13	0.24	4.4×10^{-2}	0.14	6.9×10^{-2}	9.2×10^{-2}	0.20	8.1×10^{-2}	4.1×10^{-2}	4.8×10^{-2}	2.3×10^{-2}
Selenium	7.3×10^{-3}	1.7×10^{-2}	9.7×10^{-3}	6.4×10^{-3}	9.3×10^{-3}	5.0×10^{-3}	1.1×10^{-2}	6.6×10^{-3}	4.6×10^{-3}	6.5×10^{-3}	2.5×10^{-2}	2.1×10^{-3}	4.3×10^{-3}	2.6×10^{-2}
Silver	4.2×10^{-3}	3.4×10^{-2}	6.4×10^{-2}	4.2×10^{-3}	1.4×10^{-2}	3.7×10^{-3}	2.2×10^{-2}	4.7×10^{-2}	3.2×10^{-3}	1.2×10^{-2}	1.7×10^{-2}	2.9×10^{-2}	1.2×10^{-2}	3.3×10^{-3}
Strontium	0.36	0.50	0.78	0.77	0.47	0.25	0.33	0.51	0.51	0.31	0.41	9.8×10^{-2}	0.52	2.7×10^{-2}
Thallium	1.9×10^{-3}	7.2×10^{-3}	8.5×10^{-3}	0.13	2.7×10^{-3}	1.2×10^{-3}	4.4×10^{-3}	5.5×10^{-3}	7.8×10^{-2}	1.7×10^{-3}	5.6×10^{-3}	9.7×10^{-4}	3.3×10^{-4}	1.8×10^{-3}
Uranium	1.2×10^{-3}	2.1×10^{-3}	1.7×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	7.2×10^{-4}	1.4×10^{-3}	1.1×10^{-3}	8.6×10^{-4}	8.6×10^{-4}	6.3×10^{-4}	3.2×10^{-4}	1.6×10^{-2}	9.1×10^{-5}
Vanadium	5.5×10^{-2}	6.4×10^{-2}	9.2×10^{-2}	8.7×10^{-2}	5.9×10^{-2}	4.5×10^{-2}	5.1×10^{-2}	7.0×10^{-2}	6.3×10^{-2}	4.7×10^{-2}	3.8×10^{-2}	1.9×10^{-2}	2.5×10^{-2}	6.8×10^{-3}
Zinc	0.78	4.8	8.2	2.6	4.3	0.54	3.0	6.2	1.6	3.1	7.1	2.3	7.2	1.6×10^{1}
Zirconium	8.3×10^{-2}	0.14	0.12	8.3×10^{-2}	0.10	5.2×10^{-2}	8.5×10^{-2}	7.4×10^{-2}	5.2×10^{-2}	6.2×10^{-2}	2.9×10^{-2}	1.6×10^{-2}	1.8×10^{-2}	7.4×10^{-4}

GH Galena Hill
MT Mackeno Tailings
VT Valley Tailings
SK Silver King
SMQ South McQuesten
UKHM Entirety of Keno Hill area

Table 4.23 Calculated Intakes for Toddler at South McQuesten Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))														Dermal (mg/(kg-d))	Inhalation (mg/(kg-d))
	Water	Fish	Hare	Marmot	Beaver	Moose	Caribou	Sheep	Grouse	Mallard	Tea	Berries	Soil	Total		
Antimony	1.3×10^{-5}	3.9×10^{-6}	1.2×10^{-6}	5.0×10^{-7}	6.3×10^{-5}	2.5×10^{-5}	4.7×10^{-6}	1.4×10^{-7}	1.0×10^{-6}	5.5×10^{-7}	-	3.5×10^{-7}	1.8×10^{-6}	1.2×10^{-4}	9.5×10^{-7}	8.7×10^{-10}
Arsenic	4.0×10^{-5}	6.1×10^{-5}	1.0×10^{-5}	4.2×10^{-6}	1.5×10^{-5}	2.0×10^{-4}	4.1×10^{-5}	1.2×10^{-6}	1.1×10^{-5}	3.2×10^{-5}	-	3.5×10^{-7}	9.7×10^{-6}	4.3×10^{-4}	1.5×10^{-6}	4.7×10^{-9}
Barium	3.7×10^{-4}	1.3×10^{-4}	1.1×10^{-5}	1.1×10^{-5}	9.4×10^{-5}	1.0×10^{-4}	5.1×10^{-6}	2.2×10^{-6}	1.4×10^{-6}	4.6×10^{-7}	-	7.1×10^{-5}	2.1×10^{-5}	8.3×10^{-4}	1.1×10^{-5}	1.0×10^{-8}
Cadmium	3.6×10^{-6}	1.0×10^{-4}	8.4×10^{-7}	1.6×10^{-7}	1.2×10^{-5}	6.2×10^{-5}	1.2×10^{-6}	4.6×10^{-8}	5.4×10^{-6}	3.3×10^{-6}	-	2.8×10^{-6}	1.4×10^{-6}	2.0×10^{-4}	7.4×10^{-8}	6.8×10^{-10}
Chromium	4.1×10^{-6}	5.2×10^{-5}	5.7×10^{-6}	2.9×10^{-6}	2.5×10^{-5}	7.8×10^{-5}	7.4×10^{-6}	7.4×10^{-7}	1.8×10^{-6}	1.5×10^{-7}	-	1.4×10^{-6}	1.5×10^{-6}	1.8×10^{-4}	8.1×10^{-7}	7.5×10^{-10}
Cobalt	8.7×10^{-6}	2.9×10^{-5}	8.2×10^{-7}	2.8×10^{-7}	1.3×10^{-5}	9.5×10^{-6}	5.0×10^{-7}	8.1×10^{-8}	3.7×10^{-6}	8.2×10^{-7}	-	3.5×10^{-7}	2.9×10^{-6}	7.0×10^{-5}	1.6×10^{-6}	1.4×10^{-9}
Copper	2.4×10^{-5}	1.6×10^{-4}	4.1×10^{-5}	3.1×10^{-5}	8.9×10^{-4}	1.1×10^{-3}	6.1×10^{-5}	6.9×10^{-6}	3.2×10^{-6}	1.1×10^{-6}	-	3.5×10^{-5}	3.4×10^{-6}	2.3×10^{-3}	1.1×10^{-6}	1.6×10^{-9}
Lead	4.3×10^{-4}	2.2×10^{-4}	1.2×10^{-5}	4.7×10^{-6}	1.6×10^{-4}	5.4×10^{-4}	1.6×10^{-4}	1.4×10^{-6}	6.7×10^{-6}	8.4×10^{-6}	-	3.5×10^{-7}	3.1×10^{-5}	1.6×10^{-3}	9.8×10^{-7}	1.5×10^{-8}
Manganese	2.1×10^{-3}	3.5×10^{-3}	3.2×10^{-4}	2.0×10^{-4}	3.1×10^{-3}	4.0×10^{-3}	3.9×10^{-4}	4.3×10^{-5}	1.4×10^{-6}	7.2×10^{-7}	-	9.6×10^{-4}	2.4×10^{-4}	1.5×10^{-2}	1.3×10^{-4}	1.2×10^{-7}
Mercury	9.1×10^{-8}	4.0×10^{-5}	7.5×10^{-8}	4.8×10^{-8}	2.5×10^{-6}	3.9×10^{-6}	2.4×10^{-7}	1.1×10^{-8}	3.0×10^{-10}	2.1×10^{-10}	-	3.5×10^{-8}	5.4×10^{-9}	4.7×10^{-5}	2.9×10^{-9}	2.6×10^{-12}
Molybdenum	3.1×10^{-6}	1.0×10^{-4}	2.1×10^{-7}	7.9×10^{-8}	8.3×10^{-6}	9.5×10^{-6}	1.7×10^{-7}	1.8×10^{-8}	6.5×10^{-8}	3.2×10^{-8}	-	2.5×10^{-6}	1.0×10^{-7}	1.3×10^{-4}	5.5×10^{-9}	5.1×10^{-11}
Nickel	4.9×10^{-5}	5.5×10^{-4}	3.5×10^{-5}	1.3×10^{-5}	1.4×10^{-4}	3.3×10^{-4}	1.6×10^{-5}	3.8×10^{-6}	4.4×10^{-6}	4.1×10^{-7}	-	1.0×10^{-5}	1.1×10^{-5}	1.2×10^{-3}	4.9×10^{-6}	5.3×10^{-9}
Selenium	2.1×10^{-6}	1.4×10^{-4}	2.2×10^{-5}	1.1×10^{-5}	2.2×10^{-4}	5.9×10^{-4}	1.6×10^{-5}	2.4×10^{-6}	3.5×10^{-6}	4.9×10^{-6}	-	6.9×10^{-7}	1.5×10^{-7}	1.0×10^{-3}	8.2×10^{-9}	7.5×10^{-11}
Silver	5.4×10^{-6}	4.6×10^{-6}	8.0×10^{-7}	3.2×10^{-7}	1.2×10^{-5}	3.4×10^{-5}	4.7×10^{-6}	9.4×10^{-8}	3.1×10^{-7}	2.2×10^{-7}	-	3.5×10^{-8}	7.1×10^{-7}	6.4×10^{-5}	9.4×10^{-7}	3.4×10^{-10}
Strontium	9.4×10^{-4}	1.2×10^{-3}	2.0×10^{-5}	7.0×10^{-6}	8.2×10^{-4}	9.3×10^{-4}	9.8×10^{-6}	1.5×10^{-6}	5.5×10^{-7}	2.1×10^{-6}	-	8.5×10^{-6}	4.1×10^{-6}	3.9×10^{-3}	2.2×10^{-6}	2.0×10^{-9}
Thallium	1.5×10^{-7}	6.2×10^{-6}	7.8×10^{-7}	9.2×10^{-7}	4.6×10^{-6}	1.4×10^{-5}	2.2×10^{-6}	1.9×10^{-7}	3.1×10^{-7}	1.9×10^{-6}	-	6.9×10^{-8}	6.6×10^{-9}	3.1×10^{-5}	3.5×10^{-10}	3.2×10^{-12}
Uranium	5.0×10^{-6}	3.3×10^{-7}	7.7×10^{-9}	6.1×10^{-9}	1.2×10^{-6}	8.8×10^{-6}	9.6×10^{-9}	1.3×10^{-9}	1.7×10^{-8}	6.9×10^{-7}	-	1.4×10^{-7}	-	1.6×10^{-5}	-	-
Vanadium	3.5×10^{-6}	1.6×10^{-5}	3.6×10^{-6}	1.7×10^{-6}	5.7×10^{-5}	8.7×10^{-5}	3.7×10^{-6}	4.5×10^{-7}	3.6×10^{-6}	2.9×10^{-6}	-	1.7×10^{-6}	2.3×10^{-6}	1.8×10^{-4}	1.2×10^{-6}	1.1×10^{-9}
Zinc	4.0×10^{-4}	1.7×10^{-2}	2.3×10^{-2}	7.8×10^{-3}	2.3×10^{-1}	1.6	2.9×10^{-2}	1.9×10^{-3}	1.2×10^{-4}	1.1×10^{-4}	-	1.4×10^{-4}	1.0×10^{-4}	1.9	5.6×10^{-5}	5.1×10^{-8}

Notes:
Assumed toddler does not ingest medicinal tea
No data on uranium concentration in soil therefore intake from soil ingestion, dermal contact and inhalation pathways not evaluated
Intake through inhalation converted from mg/m^3 to mg/(kg d) using toddler inhalation rate of 8.31 m^3/d and body weight of 16.5 kg

Table 4.24 Calculated Intakes for Toddler at Galena Hill Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))														Dermal (mg/(kg-d))	Inhalation (mg/(kg-d))
	Water	Fish	Hare	Marmot	Beaver	Moose	Caribou	Sheep	Grouse	Mallard	Tea	Berries	Soil	Total		
Antimony	3.0×10^{-6}	4.6×10^{-6}	1.5×10^{-7}	7.7×10^{-8}	9.5×10^{-6}	2.5×10^{-5}	4.7×10^{-6}	1.9×10^{-8}	1.1×10^{-7}	5.5×10^{-7}	-	3.5×10^{-7}	1.6×10^{-7}	4.9×10^{-5}	8.5×10^{-8}	7.8×10^{-11}
Arsenic	7.2×10^{-5}	1.4×10^{-4}	2.0×10^{-6}	8.5×10^{-7}	2.1×10^{-5}	2.0×10^{-4}	4.1×10^{-5}	2.4×10^{-7}	2.0×10^{-6}	3.2×10^{-5}	-	3.5×10^{-7}	1.8×10^{-6}	5.2×10^{-4}	2.9×10^{-7}	8.9×10^{-10}
Barium	3.2×10^{-4}	8.8×10^{-4}	1.8×10^{-5}	4.2×10^{-6}	1.3×10^{-4}	1.0×10^{-4}	5.1×10^{-6}	1.0×10^{-6}	4.3×10^{-6}	4.6×10^{-7}	-	7.1×10^{-5}	5.6×10^{-5}	1.6×10^{-3}	3.0×10^{-5}	2.7×10^{-8}
Cadmium	1.0×10^{-6}	6.6×10^{-5}	7.2×10^{-7}	2.3×10^{-8}	7.9×10^{-6}	6.2×10^{-5}	1.2×10^{-6}	6.6×10^{-9}	4.4×10^{-6}	3.3×10^{-6}	-	2.8×10^{-6}	1.8×10^{-7}	1.5×10^{-4}	9.8×10^{-9}	9.0×10^{-11}
Chromium	1.5×10^{-5}	4.3×10^{-5}	4.5×10^{-6}	1.9×10^{-6}	3.8×10^{-5}	7.8×10^{-5}	7.4×10^{-6}	5.3×10^{-7}	1.5×10^{-6}	1.5×10^{-7}	-	1.4×10^{-6}	1.5×10^{-6}	1.9×10^{-4}	7.7×10^{-7}	7.1×10^{-10}
Cobalt	1.1×10^{-5}	5.2×10^{-5}	3.1×10^{-7}	7.4×10^{-8}	1.2×10^{-5}	9.5×10^{-6}	5.0×10^{-7}	2.1×10^{-8}	1.4×10^{-6}	8.2×10^{-7}	-	3.5×10^{-7}	6.7×10^{-7}	8.8×10^{-5}	3.6×10^{-7}	3.3×10^{-10}
Copper	4.9×10^{-5}	2.7×10^{-4}	1.8×10^{-5}	5.4×10^{-6}	8.5×10^{-4}	1.1×10^{-3}	6.1×10^{-5}	1.6×10^{-6}	2.2×10^{-6}	1.1×10^{-6}	-	3.5×10^{-5}	2.7×10^{-6}	2.4×10^{-3}	8.6×10^{-7}	1.3×10^{-9}
Lead	2.1×10^{-4}	1.3×10^{-4}	2.0×10^{-6}	8.1×10^{-7}	4.2×10^{-5}	5.4×10^{-4}	1.6×10^{-4}	2.3×10^{-7}	1.1×10^{-6}	8.4×10^{-6}	-	3.5×10^{-7}	5.1×10^{-6}	1.1×10^{-3}	1.6×10^{-7}	2.5×10^{-9}
Manganese	3.7×10^{-4}	2.9×10^{-3}	1.9×10^{-4}	1.4×10^{-4}	1.1×10^{-3}	4.0×10^{-3}	3.9×10^{-4}	2.8×10^{-5}	7.7×10^{-7}	7.2×10^{-7}	-	9.6×10^{-4}	5.8×10^{-5}	1.0×10^{-2}	3.1×10^{-5}	2.8×10^{-8}
Mercury	4.5×10^{-8}	2.0×10^{-5}	8.0×10^{-8}	4.6×10^{-8}	1.3×10^{-6}	3.9×10^{-6}	2.4×10^{-7}	1.1×10^{-8}	3.5×10^{-10}	2.1×10^{-10}	-	3.5×10^{-8}	7.6×10^{-9}	2.6×10^{-5}	4.0×10^{-9}	3.7×10^{-12}
Molybdenum	2.5×10^{-6}	5.6×10^{-5}	1.3×10^{-7}	5.7×10^{-8}	6.6×10^{-6}	9.5×10^{-6}	1.7×10^{-7}	1.4×10^{-8}	4.5×10^{-8}	3.2×10^{-8}	-	2.5×10^{-6}	1.3×10^{-7}	7.8×10^{-5}	6.8×10^{-9}	6.3×10^{-11}
Nickel	2.3×10^{-5}	3.0×10^{-4}	1.1×10^{-5}	3.2×10^{-6}	7.9×10^{-5}	3.3×10^{-4}	1.6×10^{-5}	8.3×10^{-7}	1.3×10^{-6}	4.1×10^{-7}	-	1.0×10^{-5}	2.0×10^{-6}	7.8×10^{-4}	8.9×10^{-7}	9.6×10^{-10}
Selenium	3.0×10^{-6}	9.7×10^{-4}	1.4×10^{-5}	8.3×10^{-6}	1.4×10^{-4}	5.9×10^{-4}	1.6×10^{-5}	1.9×10^{-6}	2.1×10^{-6}	4.9×10^{-6}	-	6.9×10^{-7}	1.1×10^{-7}	1.8×10^{-3}	5.8×10^{-9}	5.3×10^{-11}
Silver	3.6×10^{-6}	3.9×10^{-6}	2.4×10^{-7}	1.0×10^{-7}	7.7×10^{-6}	3.4×10^{-5}	4.7×10^{-6}	2.9×10^{-8}	9.4×10^{-8}	2.2×10^{-7}	-	3.5×10^{-8}	2.1×10^{-7}	5.5×10^{-5}	2.8×10^{-7}	1.0×10^{-10}
Strontium	3.9×10^{-4}	3.8×10^{-3}	3.0×10^{-5}	5.4×10^{-6}	5.2×10^{-4}	9.3×10^{-4}	9.8×10^{-6}	1.2×10^{-6}	9.1×10^{-7}	2.1×10^{-6}	-	8.5×10^{-6}	5.3×10^{-6}	5.7×10^{-3}	2.8×10^{-6}	2.6×10^{-9}
Thallium	2.0×10^{-7}	1.6×10^{-6}	5.6×10^{-7}	6.4×10^{-7}	1.4×10^{-6}	1.4×10^{-5}	2.2×10^{-6}	1.3×10^{-7}	2.5×10^{-7}	1.9×10^{-6}	-	6.9×10^{-8}	6.4×10^{-9}	2.3×10^{-5}	3.4×10^{-10}	3.1×10^{-12}
Uranium	2.8×10^{-6}	2.2×10^{-6}	6.8×10^{-9}	5.1×10^{-9}	1.3×10^{-6}	8.8×10^{-6}	9.6×10^{-9}	1.1×10^{-9}	1.6×10^{-8}	6.9×10^{-7}	-	1.4×10^{-7}	-	1.6×10^{-5}	-	-
Vanadium	2.2×10^{-5}	4.6×10^{-5}	3.5×10^{-6}	1.6×10^{-6}	1.9×10^{-4}	8.7×10^{-5}	3.7×10^{-6}	4.3×10^{-7}	3.5×10^{-6}	2.9×10^{-6}	-	1.7×10^{-6}	2.3×10^{-6}	3.6×10^{-4}	1.2×10^{-6}	1.1×10^{-9}
Zinc	1.7×10^{-4}	1.0×10^{-2}	7.8×10^{-3}	1.4×10^{-3}	1.5×10^{-1}	1.6	2.9×10^{-2}	3.2×10^{-4}	4.0×10^{-5}	1.1×10^{-4}	-	1.4×10^{-4}	1.2×10^{-5}	1.8	6.2×10^{-6}	5.7×10^{-9}

Notes:
Assumed toddler does not ingest medicinal tea
No data on uranium concentration in soil therefore intake from soil ingestion, dermal contact and inhalation pathways not evaluated
Intake through inhalation converted from mg/m^3 to mg/(kg d) using toddler inhalation rate of 8.31 m^3/d and body weight of 16.5 kg

Table 4.25 Ingestion Intakes by Pathways for Toddler at South McQuesten Area

COPC	% Intake by Ingestion Pathways												
	Water	Fish	Hare	Marmot	Beaver	Moose	Caribou	Sheep	Grouse	Mallard	Tea	Berries	Soil
Antimony	12%	3%	1%	0.4%	54%	22%	4%	0.1%	0.9%	0.5%	-	0.3%	2%
Arsenic	9%	14%	2%	1%	4%	47%	10%	0.3%	2%	7%	-	0.1%	2%
Barium	45%	16%	1%	1%	11%	13%	0.6%	0.3%	0.2%	0.1%	-	9%	3%
Cadmium	2%	53%	0.4%	0.1%	6%	32%	0.6%	0.02%	3%	2%	-	1%	0.7%
Chromium	2%	29%	3%	2%	14%	43%	4%	0.4%	1.0%	0.1%	-	0.8%	0.8%
Cobalt	13%	41%	1%	0.4%	19%	14%	0.7%	0.1%	5%	1%	-	0.5%	4%
Copper	1%	7%	2%	1%	38%	46%	3%	0.3%	0.1%	0.05%	-	1%	0.1%
Lead	27%	14%	0.7%	0.3%	10%	34%	10%	0.1%	0.4%	0.5%	-	0.02%	2%
Manganese	14%	24%	2%	1%	21%	27%	3%	0.3%	<0.01%	<0.01%	-	6%	2%
Mercury	0.2%	85%	0.2%	0.1%	5%	8%	1%	0.02%	<0.01%	<0.01%	-	0.1%	0.01%
Molybdenum	2%	81%	0.2%	0.1%	6%	7%	0.1%	0.01%	0.05%	0.02%	-	2%	0.1%
Nickel	4%	48%	3%	1%	12%	29%	1%	0.3%	0.4%	0.04%	-	1%	0.9%
Selenium	0.2%	14%	2%	1%	21%	58%	2%	0.2%	0.3%	0.5%	-	0.1%	0.02%
Silver	9%	7%	1%	0.5%	19%	54%	7%	0.1%	0.5%	0.4%	-	0.1%	1%
Strontium	24%	30%	0.5%	0.2%	21%	24%	0.3%	0.04%	0.01%	0.05%	-	0.2%	0.1%
Thallium	0.5%	20%	3%	3%	15%	44%	7%	0.6%	1%	6%	-	0.2%	0.02%
Uranium	31%	2%	0.05%	0.04%	7%	55%	0.1%	<0.01%	0.1%	4%	-	0.9%	-
Vanadium	2%	9%	2%	0.9%	31%	47%	2%	0.2%	2%	2%	-	0.9%	1%
Zinc	0.02%	0.9%	1%	0.4%	12%	84%	2%	0.1%	<0.01%	<0.01%	-	<0.01%	<0.01%

Notes:
Assumed toddler does not ingest medicinal tea
No data on uranium concentration in soil therefore intake from soil ingestion not calculated
Values may not sum to 100% due to rounding

Table 4.26 Ingestion Intakes by Pathways for Toddler at Galena Hill Area

COPC	% Intake by Ingestion Pathways												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Tea**	**Berries**	**Soil**
Antimony	6%	9%	0.3%	0.2%	20%	52%	10%	0.04%	0.2%	1.1%	-	0.7%	0.3%
Arsenic	14%	27%	0.4%	0.2%	4%	39%	8%	0.05%	0.4%	6%	-	0.1%	0.4%
Barium	20%	55%	1%	0.3%	8%	6%	0.3%	0.1%	0.3%	0.03%	-	4%	4%
Cadmium	1%	44%	0.5%	0.02%	5%	42%	0.8%	<0.01%	3%	2%	-	2%	0.1%
Chromium	8%	22%	2%	1.0%	20%	41%	4%	0.3%	0.8%	0.1%		0.7%	0.8%
Cobalt	12%	59%	0.4%	0.1%	14%	11%	0.6%	0.02%	2%	0.9%	-	0.4%	0.8%
Copper	2%	11%	0.8%	0.2%	36%	46%	3%	0.1%	0.1%	0.04%	-	1%	0.1%
Lead	19%	12%	0.2%	0.1%	4%	49%	15%	0.02%	0.1%	0.8%	-	0.03%	0.5%
Manganese	4%	29%	2%	1%	10%	40%	4%	0.3%	<0.01%	<0.01%	-	10%	0.6%
Mercury	0.2%	78%	0.3%	0.2%	5%	15%	0.9%	0.04%	<0.01%	<0.01%	-	0.1%	0.03%
Molybdenum	3%	72%	0.2%	0.1%	8%	12%	0.2%	0.02%	0.06%	0.04%	-	3%	0.2%
Nickel	3%	39%	1%	0.4%	10%	42%	2%	0.1%	0.2%	0.05%	-	1%	0.3%
Selenium	0.2%	55%	0.8%	0.5%	8%	34%	1%	0.1%	0.1%	0.3%	-	0.04%	0.01%
Silver	6%	7%	0%	0.2%	14%	62%	9%	0.1%	0.2%	0.4%	-	0.1%	0.4%
Strontium	7%	67%	0.5%	0.1%	9%	16%	0.2%	0.02%	0.02%	0.04%	-	0.1%	0.1%
Thallium	0.9%	7%	2%	3%	6%	61%	10%	0.6%	1%	8%	-	0.3%	0.03%
Uranium	18%	14%	0.04%	0.03%	8%	55%	0.1%	0.007%	0.1%	4%	-	0.9%	-
Vanadium	6%	13%	1%	0.4%	52%	24%	1%	0.1%	1%	0.8%	-	0.5%	0.6%
Zinc	0.01%	0.6%	0.4%	0.1%	8%	89%	2%	0.0%	<0.01%	<0.01%	-	<0.01%	<0.01%

Notes:
Assumed toddler does not ingest medicinal tea
No data on uranium concentration in soil therefore intake from soil ingestion not calculated
Values may not sum to 100% due to rounding

5.0 HAZARD ASSESSMENT

The hazard assessment phase of an ecological and/or human health risk assessment involves identification of chemical concentrations or doses which have been shown to have adverse effects on the receptors (ecological species or humans) of concern. The exposure concentrations or doses are generally determined from controlled laboratory tests or from epidemiology studies and are used to establish toxicity benchmarks which are protective of the receptors. It should be noted that exposure above a toxicity benchmark does not mean that an effect will occur, but instead means that there is an increased risk of an adverse effect occurring.

5.1 ECOLOGICAL TOXICITY EVALUATION

Within the Ecological Risk Assessment (ERA) framework, assessment endpoints for ecological receptors are based on potential effects at population or community levels. At these levels of biological organization, population and community characteristics can be defined over fairly extended temporal and spatial scales making the potential for the direct measurement of effects challenging (Environment Canada 1997).

Due to the difficulty in measuring direct effects on population assessment endpoints, "measurement endpoints" are adopted to provide a framework for the evaluation of predicted effects. A measurement endpoint is defined as "*…a quantitative summary of the results of a toxicity test, a biological study, or other activity intended to reveal the effects of a substance*" (Suter 1993). In lieu of direct assessment endpoint effects measures, the adoption of measurement endpoints provides a consistent basis for the evaluation of potential effects due to exposure to constituents.

Measurement endpoints are commonly selected at the individual level of biological organization, and are typically based on exposure responses that represent key population and community characteristics such as reproduction and abundance (Environment Canada 1997). Such measurement endpoints are commonly based on literature-derived toxicity dose-response relationships, examined through laboratory experimentation (i.e., the response of a particular organism to a certain level of exposure). When derived from toxicity studies, such measurement endpoints are often referred to as toxicity benchmarks or toxicological reference values (TRVs).

These TRVs are used in risk assessments to judge whether the predicted (estimated) exposures (or intakes) may potentially have an adverse effect on ecological species. Site-specific information was incorporated into the selection process for TRVs where available. A discussion of selected literature and the associated TRVs are provided in the following sections.

TRVs are based on exposure levels in the case of aquatic species and total intakes for terrestrial species. Unless otherwise stipulated, it was assumed that the entire amount of each COPC taken into the stomach and/or lungs of a terrestrial species is transferred into the body stream of the species.

5.1.1 Aquatic Toxicity Evaluation

5.1.1.1 Water Quality

In this assessment, EC_{20} (effects concentration) values which have the potential to affect 20% of the population were used to determine whether COPC are likely to cause adverse effects in aquatic receptors. An EC_{25} value is suggested by Environment Canada for use in risk assessments (Environment Canada 1997); however, an EC_{20} concentration was chosen for this assessment because effects or changes in populations in this range are generally not distinguishable from natural variation. In addition, a 20% reduction in rapidly growing populations (e.g. phytoplankton or zooplankton) might be quickly offset by reproduction once the chemical stress is removed or may be offset by growth and immigration from non-affected nearby locations.

Where possible, EC data were collected over lethal concentration (LC; i.e., mortality) data, and values were converted to EC_{20} values. Different models exist for translating chemical exposure (or dose) to toxic responses. For EC_{50} toxicity values, in the absence of detailed dose-response functions, a linear approximation is commonly applied assuming zero effect at zero exposure. This linearization is conservative since the predicted effect will be greater than that observed using the commonly encountered sigmoidal dose-response function for low dose exposures. For acute toxicity values (LC_{50} values derived from 96-hour tests), a factor of 10 was applied in the derivation of appropriate toxicity benchmarks (EC_{20} values) for this assessment (Environment Canada/Health Canada 2003). For LC_{50} data derived from chronic tests, a factor of 4 was applied to determine the EC_{20} benchmark. This is an empirical factor based on the results of other toxicity tests.

It was not the intent of this assessment to extensively search the primary literature to obtain TRVs; rather, this assessment relied on TRVs that have been collated and peer reviewed by various agencies for use in risk assessments. The U.S. Department of Energy (DOE) database (Suter and Tsao 1996) on aquatic TRVs was the primary source of toxicity information. This database contains TRVs for the protection of aquatic life from chemicals in water. EC_{20} values provided in this database were selected as appropriate TRVs. The advantage to using these TRVs is that they were developed for use in risk assessments and have been peer reviewed. This database provides documentation on the sources and derivations of the values and discusses the relative conservatisms in the TRVs.

If data were not available from the U.S. DOE database then the U.S. EPA Ecotoxicology (ECOTOX) database was consulted for infilling purposes. The data summarized in this database are from a variety of sources, including peer reviewed literature. Toxicity information provided in the CCME Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME 2011) was also used in the development of TRVs for this assessment.

When more than 20 acceptable records for a biotic group were available, the 5th percentile value of the adjusted chronic EC_{20} values was selected as the TRV. When fewer than 20 records were available, then the minimum of the acceptable adjusted chronic EC_{20} values was selected. If the selected TRV was lower than the existing CCME guideline value for the protection of freshwater aquatic life (CCME 2011), then the CCME value was selected as the TRV. It is acknowledged that these databases may not have the most recent data; however, the TRVs selected are, in our opinion, appropriate.

Decision rules for the selection of test species were developed around the available data. For aquatic plants, the lowest of the toxicity values for *Lemna* sp. or *Myriophyllum* sp. test species was chosen. These two species are considered to be the most sensitive aquatic plant species for which toxicity data are available. For benthic invertebrates, the lowest available toxicity values for any invertebrate test species were used. For the fish species, data were chosen for the species based on feeding habits (i.e., predatory or forage). The lowest toxicity value of these species was chosen to represent the respective predatory or forage fish. However, if the selected TRV was lower than the existing CCME guideline (CCME 2011) then the CCME value was selected as the TRV. If the CCME guideline was dependent on water hardness, then the site-specific average water hardness of 411 mg/L $CaCO_3$ (rounded to 400 mg/L $CaCO_3$) was used to develop a site-specific TRV.

The references, test species and rationale for the selection of each TRV selected for the assessment are provided in Table 5.1, while the TRVs are summarized in Table 5.2. It should be noted that the aquatic TRVs presented for benthic invertebrates are all based on water exposure only; sediment exposure is discussed and assessed separately using toxicity data based on sediment toxicity studies.

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment

Aquatic Receptor	Antimony (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	--	--	--	--	No data available.
Phytoplankton	*Selenastrum capricornutum*	0.61	0.24	Kimball (n.d.)	From Suter and Tsao (1996); 4-d EC_{50}; derived an EC_{20} by linear extrapolation.
Benthic Invertebrates	*Gammarus pseudolimnaeus*	26	2.6	Brooke *et al*. 1986	4-day LC_{50}; derived TRV using a factor of 10 based on an empirical relationship between an acute LC_{50} and EC_{20}.
Zooplankton	*Daphnia magna*	5.4	1.35	Kimball (n.d.)	From Suter and Tsao (1996); 28-d LC_{50}; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.
Predator Fish	*Oncorhynchus mykiss*	16	4	Doe *et al*. 1987	30-day LC_{50}; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.
Forage Fish	*Pimephales promelas*	--	2.31	Kimball (n.d.)	From Suter and Tsao (1996); lowest chronic test EC_{20} – early life stage tests.

Aquatic Receptor	Arsenic (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Myriophyllum* sp.	0.63	0.25	Jenner and Janssen-Mommen 1993	From U.S. EPA ECOTOX; 14-d EC_{50} (population); derived an EC_{20} by linear extrapolation.
Phytoplankton	*Scenedesmus obliquus*	0.05	0.02	Vocke *et al*. 1980	From CCME (1999); 14-d EC_{50} (growth); derived an EC_{20} by linear extrapolation.
Benthic Invertebrates	*Calanus* sp.	--	0.32	Borgmann *et al*. 1980	From CCME (1999); 14-d EC_{20}; used as TRV.
Zooplankton	*Daphnia* sp.	--	0.91	Call *et al*. 1983; Lima *et al*. 1984	From Suter and Tsao (1996); lowest chronic test EC_{20} – life-cycle tests; used as TRV.
Predator Fish	*Oncorhynchus mykiss*	0.55	0.14	Birge *et al*. 1979a	From CCME (1999); 28-d LC_{50}; derived TRV using a factor of 4 based on empirical relationship between a chronic LC_{50} and an EC_{20}.
Forage Fish	*Carassius auratus*	0.49	0.12	Birge *et al*. 1979b	From U.S. EPA ECOTOX; lowest value for fathead minnow and goldfish based on 7-d LC_{50} (mortality); derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment (Cont'd)

Aquatic Receptor	Cadmium (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Myriophyllum*	7.4	3.0	Stanley 1974	From U.S. EPA ECOTOX; EC_{50} (population) 32-d; derived an EC_{20} by linear extrapolation.
Phytoplankton	*Scenedesmus*	0.008	0.003	Fargasova 1994	From U.S. EPA ECOTOX; EC_{50} (population) 12-d; derived an EC_{20} by linear extrapolation.
Benthic Invertebrates	*Chironomus* sp.	1.2	0.12	Rehwoldt *et al.* 1973	From U.S. EPA ECOTOX; LC_{50} (mortality) 96-hr; derived TRV using a factor of 10 based on an empirical relationship between an acute LC_{50} and EC_{20}.
Zooplankton	*Daphnia* sp.	--	$7.5x10^{-4}$	Elnabarawy *et al.* 1986	From Suter and Tsao (1996); lowest chronic test EC_{20} – life-cycle tests; used as TRV.
Predator Fish	*Salvelinus fontinalis*	--	0.002	Carlson *et al.* 1982	From Suter and Tsao (1996); lowest chronic test EC_{20} – early life stage tests; used as TRV.
Forage Fish	*Pimephales promelas*	0.09	0.009	Hall *et al.* 1986	From IPCS (1992); 96-hr LC_{50}; derived TRV using a factor of 10 based on an empirical relationship between an acute LC_{50} and EC_{20}.

Aquatic Receptor	Chromium – based on Cr (VI) (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Microcystis aeruginosa*	--	0.002	U.S. EPA 1985	From Suter and Tsao (1996); lowest chronic test EC_{20} – early life stage test; used as TRV.
Phytoplankton	--	--	--	--	No data available.
Benthic Invertebrates	--	--	--	--	No data available.
Zooplankton	*Daphnia* sp.	--	0.006	Mount 1982	From Suter and Tsao (1996); lowest chronic test EC_{20} – early life stage test; used as TRV.
Predator Fish	*Oncorhynchus mykiss*	--	0.073	Sauter *et al.* 1976	From Suter and Tsao (1996); lowest chronic test EC_{20} – early life stage test; used as TRV.
Forage Fish	--	--	--	--	No data available.

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment (Cont'd)

Aquatic Receptor	Cobalt (mg/L)				
	Test Species	**LC/EC$_{50}$**	**TRV**	**Reference**	**Comments**
Aquatic Plants	--	--	--	--	No data available.
Phytoplankton	*Chlorella*	0.55	0.22	Coleman *et al.* 1971	From MOE (1996); EC$_{50}$ 21-d; derived an EC$_{20}$ by linear extrapolation.
Benthic Invertebrates	Cyclops	16	1.6	Baudouin and Scoppa 1974	From MOE (1996); this value is the lowest value for all test invertebrate species and is the same as the value for a mayfly. LC$_{50}$ 48-hr (acute); derived TRV using a factor of 10 based on an empirical relationship between an acute LC$_{50}$ and an EC$_{20}$.
Zooplankton	*Daphnia* sp.	--	0.005	Kimball (n.d.)	From Suter and Tsao (1996); lowest chronic test EC$_{20}$ – 28-d life-cycle tests; used as TRV.
Predator Fish	*Oncorhynchus mykiss*	0.47	0.12	Birge 1978	From MOE (1996); LC$_{50}$ embryos 28-d; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC$_{50}$ and an EC$_{20}$.
Forage Fish	*Carassius auratus*	0.81	0.20	Birge 1978	From MOE (1996); lowest value of fathead minnow, tilapia, stickleback and goldfish. LC$_{50}$ 7-d; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC$_{50}$ and an EC$_{20}$.

Aquatic Receptor	Copper (mg/L)				
	Test Species	**LC/EC$_{50}$**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Myriophyllum* sp.	0.30	0.12	Stanley 1974	From U.S. EPA ECOTOX; EC$_{50}$ (population) 32-d; derived EC$_{20}$ by linear extrapolation
Phytoplankton	*Chlorella* sp.	--	0.0040	Franklin *et al.* 2000	From EC/HC (2003); EC$_{20}$ for cell growth, cell division and cell size for *Chlorella* and *Selenastrum*
Benthic Invertebrates	*Calanus* sp.	0.8	0.080	Hooftman *et al.* 1989	From U.S. EPA ECOTOX; LC$_{50}$ (mortality) 72-hr; derived TRV using factor of 10 based on an empirical relationship between an acute LC$_{50}$ and an EC$_{20}$
Zooplankton	*Daphnia* sp.	0.02	0.0041	Mastin and Rodgers 2000	LC$_{50}$ (mortality) 48-hr; derived TRV using a factor of 10 based on an empirical relationship between an acute LC$_{50}$ and an EC$_{20}$; used CCME value since EC$_{20}$ was less than CCME value
Predator Fish	Bass	--	0.0069	U.S. DOE 2005	EC$_{25}$ bass population surface water screening benchmark; derived EC$_{20}$ by linear extrapolation.
Forage Fish	--	--	0.0077	--	CCME (2011); calculated EC$_{20}$ less than CCME guideline; average site-specific water hardness of approximately 400 mg/L as $CaCO_3$.

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment (Cont'd)

Aquatic Receptor	Iron (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	--	--	--	--	--
Phytoplankton	--	--	--	--	--
Benthic Invertebrates	--	--	--	--	--
Zooplankton	*Daphnia* sp.	5.9	1.48	Biesinger and Christensen 1972	From CCREM (1987); LC_{50} (mortality) 3-week; derived benchmark using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.
Predator Fish	*Salvelinus fontinalis*	--	7.5	Sykora *et al.* 1972; Smith *et al.* 1973	From CCREM (1987); safe concentration based on mortality of juveniles.
Forage Fish	*Pimephales promelas*	1.5	0.6	Sykora *et al.* 1972	From CCREM (1987); EC_{50} based on 50% reduction in hatchability of fathead minnow eggs; derived EC_{20} by linear extrapolation.

Aquatic Receptor	Lead (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Myriophyllum* sp.	363	145.2	Stanley 1974	From U.S. EPA ECOTOX; EC_{50} (population) 32-d; derived an EC_{20} by linear extrapolation.
Phytoplankton	*Chlorella* sp.	--	0.63	U.S. EPA 1985	From Suter and Tsao (1996); EC_{20} (growth inhibition); used as TRV.
Benthic Invertebrates	*Hyallela azteca*	--	0.019	--	CCME (2011); calculated EC_{20} less than CCME guideline; average site-specific water hardness of approximately 400 mg/L as $CaCO_3$.
Zooplankton	*Daphnia* sp.	--	0.02	Chapman *et al.* 1980	From Suter and Tsao (1996); lowest chronic EC_{20} 21-d tests; used as TRV.
Predator Fish	*Oncorhynchus mykiss*	--	0.022	Sauter *et al.* 1976	From Suter and Tsao (1996); lowest chronic test EC_{20}; used as TRV.
Forage Fish	*Carassius auratus*	1.66	0.42	Birge *et al.* 1979b	From U.S. EPA ECOTOX; lowest value of fathead minnow, snakehead catfish and goldfish LC_{50} (mortality) 7-d; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment (Cont'd)

Aquatic Receptor	Manganese (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Lemna minor*	31	12.4	Wang 1986	From U.S. EPA ECOTOX ; 4-d EC_{50} (growth); derived EC_{20} by linear extrapolation.
Phytoplankton	*Spirostomum ambiguum*	92.8	37.1	Nalecz-Jawecki and Sawicki 1998	From U.S. EPA ECOTOX; 24-hr EC_{50} (deformation); derived EC_{20} by linear extrapolation.
Benthic Invertebrates	*Dugesia gonocephala*	--	46	Palladini *et al*. 1980	From U.S. EPA ECOTOX; 8-d NOEC (locomotion); used as TRV.
Zooplankton	*Daphnia magna*	4.7	1.8	Baird *et al*. 1991	Lowest value From U.S. EPA ECOTOX; 48-hr EC_{50} (immobility); derived EC_{20} by linear extrapolation.
Predator Fish	*Oncorhynchus mykiss*	2.91	0.73	Birge 1978	Lowest value From U.S. EPA ECOTOX; 28-d LC_{50} (mortality); derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.
Forage Fish	*Carassius auratus*	8.22	2.06	Birge 1978	From U.S. EPA ECOTOX; 7-d LC_{50} (mortality); derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.

Aquatic Receptor	Mercury - Inorganic (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Microcystis aeruginosa*	--	0.005	U.S. EPA 1985	From Suter and Tsao (1996); lowest chronic test EC_{20}; used as TRV.
Phytoplankton	--	--	--	--	No data available.
Benthic Invertebrates	--	--	--	--	No data available.
Zooplankton	*Daphnia* sp.	--	0.00087	Biesinger *et al*. 1982	From Suter and Tsao (1996); lowest chronic test EC_{20}; used as TRV.
Predator Fish	--	--	--	--	No data available.
Forage Fish	*Pimephales promelas*	--	0.00087	Call *et al*. 1983	From Suter and Tsao (1996); lowest chronic test EC_{20}, early life stage test; used as TRV.

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment (Cont'd)

Aquatic Receptor	Molybdenum (mg/L)				
	Test Species	LC/EC$_{50}$	TRV	Reference	Comments
Aquatic Plants	--	--	--	--	no data available
Phytoplankton	*Chlorella* sp.	50	5.0	Sakaguchi *et al.* 1981	From U.S. DOC NTIS (1989); assumed EC$_{50}$ (growth) 96-hr; derived TRV using a factor of 10 based on an empirical relationship between an acute LC$_{50}$ and an EC$_{20}$.
Benthic Invertebrates	*Tubifex tubifex*	29	14.5	Khangarot 1991	96-hr EC$_{50}$ (immobilization); derived EC$_{20}$ by linear extrapolation
Zooplankton	*Daphnia* sp.	--	0.45	Kimball (n.d.)	From Suter and Tsao (1996); lowest chronic test EC$_{20}$, 28-d life-cycle test.
Predator Fish	*Oncorhynchus mykiss*	0.73	0.2	Birge *et al.* 1979b	From U.S. EPA ECOTOX; LC$_{50}$ (mortality) 28-d; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC$_{50}$ and an EC$_{20}$.
Forage Fish	*Carassius auratus*	60	15	Birge 1978	From CCME (1999); lowest toxicity value of fathead minnow, bluegill sunfish and goldfish. 7-d LC$_{50}$; study results had a large CI; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC$_{50}$ and an EC$_{20}$.

Aquatic Receptor	Nickel (mg/L)				
	Test Species	LC/EC$_{50}$	TRV	Reference	Comments
Aquatic Plants	*Lemna* sp.	0.45	0.18	Wang 1986	From U.S. EPA ECOTOX; EC$_{50}$ (growth) 4-d; derived EC$_{20}$ by linear extrapolation.
Phytoplankton	*Selenastrum capricornutum*	--	0.03	Chao and Chen 2000	Based on an EC$_{10}$ of 0.016 mg/L for 10% growth reduction in batch tests; derived EC$_{20}$ by linear extrapolation.
Benthic Invertebrates	*Chironomus* sp.	8.6	0.86	Rehwoldt *et al.* 1973	From U.S. EPA ECOTOX; LC$_{50}$ (mortality) 96-hr; derived TRV using a factor of 10 based on an empirical relationship between an acute LC$_{50}$ and an EC$_{20}$.
Zooplankton	*Daphnia* sp.	--	0.06	Munzinger 1990	From Suter and Tsao (1996); lowest chronic test EC$_{20}$; used as TRV.
Predator Fish	*Oncorhynchus mykiss*	--	0.06	Nebeker *et al.* 1985	From Suter and Tsao (1996); lowest chronic test EC$_{20}$, early life stage test; used as TRV.
Forage Fish	*Pimephales promelas*	2.9	0.29	Lind *et al.* 1978	From U.S. EPA ECOTOX; LC$_{50}$ (mortality) 96-hr; derived TRV using a factor of 10 based on an empirical relationship between an acute LC$_{50}$ and an EC$_{20}$.

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment (Cont'd)

Aquatic Receptor	Selenium (mg/L)				
	Test Species	LC/EC_{50}	TRV	Reference	Comments
Aquatic Plants	*Lemna* sp.	1.7	0.68	Jenner and Janssen-Mommen 1993	From U.S. EPA ECOTOX; EC_{50} (population) 14-d; derived EC_{20} by linear extrapolation.
Phytoplankton	*Scenedesmus* sp.	--	0.19	Vocke *et al.* 1980	From Suter and Tsao (1996); chronic 14-d EC_{20} for reduced growth; used as TRV.
Benthic Invertebrates	*Chironomus* sp.	1.8	0.18	Ingersoll *et al.* 1990	From U.S. EPA ECOTOX; LC_{50} (immobility) 48-hr; derived TRV using a factor of 10 based on an empirical relationship between an acute LC_{50} and an EC_{20}.
Zooplankton	*Daphnia* sp.	--	0.025	Johnston 1987	From Suter and Tsao (1996); lowest chronic test EC_{20}, 28-d; used as TRV.
Predator Fish	*Oncorhynchus mykiss*	--	0.05	Goettl and Davies 1976	From Suter and Tsao (1996); lowest chronic test EC_{20}, early life stage tests; used as TRV.
Forage Fish	*Pimephales promelas*	0.6	0.15	Halter *et al.* 1980	From U.S. EPA ECOTOX; LC_{50} (mortality) 14-d; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.

Aquatic Receptor	Silver (mg/L)				
	Test Species	LC/EC_{50}	TRV	Reference	Comments
Aquatic Plants	--	--	--	--	No data available.
Phytoplankton	--	--	--	--	No data available.
Benthic Invertebrates	--	--	--	--	No data available.
Zooplankton	*Daphnia* sp.	$5.8x10^{-3}$	$5.8x10^{-4}$	Erickson *et al.* 1998	From U.S. EPA ECOTOX; 48-h LC_{50} (mortality); derived benchmark using a factor of 10 based on an empirical relationship between an acute LC_{50} and an EC_{20}.
Predator Fish	*Oncorhynchus mykiss*	$9.2x10^{-3}$	$9.2x10^{-4}$	Nebeker *et al.* 1983; Bury *et al.* 1999	From U.S. EPA ECOTOX; 96-h LC_{50} (mortality); derived benchmark using a factor of 10 based on an empirical relationship between an acute LC_{50} and an EC_{20}.
Forage Fish	*Pimephales promelas*	$1.04x10^{-2}$	$1.04x10^{-3}$	Erickson *et al.* 1998	From U.S. EPA ECOTOX; 96-h LC_{50} (mortality); derived benchmark using a factor of 10 based on an empirical relationship between an acute LC_{50} and an EC_{20}.

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment (Cont'd)

Aquatic Receptor	**Strontium (mg/L)**				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	--	--	--	--	No data available.
Phytoplankton	*Chlorella vulgaris*		150	Den Dooren de Jong 1965	From U.S. EPA ECOTOX; LOEC (Lowest Observed Effect Concentration [general population changes]); used as TRV.
Benthic Invertebrates	*Biomphalaria glabrata*	--	10	Harry and Aldrich 1963	From U.S. EPA ECOTOX; observed stress in snails, endpoint not reported but value is lower than other chronic values so is treated as a chronic EC value.
Zooplankton	*Daphnia* sp.	--	42	Biesinger and Christensen 1972	From Suter and Tsao (1996); results From a 21-d test resulting in 16% reproductive impairment; used as TRV.
Predator Fish	*Morone saxatilis*	92.8	9.3	Dwyer *et al.* 1992	From U.S. EPA ECOTOX; LC_{50} 96-h; derived TRV using a factor of 10 based on an empirical relationship between an acute LC_{50} and an EC_{20}.
Forage Fish	*Carassius auratus*	8.5	2.13	Birge 1978	From U.S. EPA ECOTOX; LC_{50} 7-d; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.

Aquatic Receptor	**Uranium (mg/L)**				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Lemna minor*	7.4	2.96	Vizon SciTec 2004	7-day IC_{50} based on growth inhibition (low hardness and alkalinity); derived an EC_{20} by linear extrapolation.
Phytoplankton	Multiple species	--	0.011	Franklin *et al.* 2000; EC/HC 2003	Geometric mean of ENEVs for three species including *Chlorella* for hardness of < 100 mg/L. Conservative compared to data on *Selenastrum capricornutum* From Vizon SciTec (2004) - 72-h IC_{50} of 0.16 mg/L based on growth inhibition (low hardness and alkalinity).
Benthic Invertebrates	*Hyallela azteca*.	8.2	0.82	Liber and White-Sobey 2000	LC_{50} 96-hr; derived TRV by dividing by a factor of 10. Data on *Hyalella azteca* (Vizon SciTec 2004) had high uncertainty and therefore, was not used.
Zooplankton	Multiple species	--	0.011	Franklin *et al.* 2000; EC/HC 2003	Geometric mean of ENEVs for *Ceriodaphnia*, *Daphnia* and *Chlorella* for hardness of < 100 mg/L. Comparable to data on *Ceriodaphnia dubia* (Vizon SciTec 2004) - 24-96 hr IC_{50} of 0.046 mg/L based on reproduction (low hardness and alkalinity).
Predator Fish	*Oncorhynchus mykiss*	6.2	0.62	Davies 1980	From U.S. EPA ECOTOX; 96-hr LC_{50} (mortality); derived TRV by dividing by a factor of 10. Comparable to data on rainbow trout (Vizon SciTec 2004) - 96-hr LC_{50} of 4.2 mg/L based on mortality of fry (low hardness and alkalinity).
Forage Fish	*Pimephales promelas*	1.6	0.16	Tarzwell and Henderson 1960	96-hr LC_{50} for fathead minnow; derived TRV by dividing by a factor of 10. Comparable to data on fathead minnow (Vizon SciTec 2004) - 7-d IC_{50} of >1.3 mg/L based on larvae growth (low hardness and alkalinity).

Table 5.1 Aquatic Toxicological Reference Values Used in the Aquatic Assessment (Cont'd)

Aquatic Receptor	Vanadium (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	--	--	--	--	No data available.
Phytoplankton	*Scenedesmus quadricauda*	2.2	0.9	Fargasova *et al.* 1999	From U.S. EPA ECOTOX; 12-day EC_{50} for growth inhibition; derived an EC_{20} based on linear extrapolation.
Benthic Invertebrates	*Chironomus plumosus*	0.24	0.024	Fargasova 1997	From U.S. EPA ECOTOX; increasing mortality From 24 to 96 hours; derived TRV using a factor of 10 based on an empirical relationship between an acute LC_{50} and an EC_{20}.
Zooplankton	*Daphnia sp.*	--	1.9	Kimball (n.d.)	From Suter and Tsao (1996); lowest chronic test EC_{20}; used as TRV.
Predator Fish	Fish species	--	0.04	Holdway and Sprague 1979	From Suter and Tsao (1996); lowest chronic test EC_{20}; used as TRV.
Forage Fish	Fish species	--	0.04	Holdway and Sprague 1979	From Suter and Tsao (1996); lowest chronic test EC_{20}; used as TRV.

Aquatic Receptor	Zinc (mg/L)				
	Test Species	**LC/EC_{50}**	**TRV**	**Reference**	**Comments**
Aquatic Plants	*Myriophyllum* sp.	21.6	8.64	Stanley 1974	From U.S. EPA ECOTOX; EC_{50} (growth) 32-d; derived EC_{20} by linear extrapolation.
Phytoplankton	*Selenastrum* sp.		0.04	Bartlett and Rabe 1974	From Suter and Tsao (1996); 7-d test EC_{20} for growth inhibition; used as TRV.
Benthic Invertebrates	*Chironomus* sp.	1.13	0.283	Phipps *et al.* 1995	From U.S. EPA ECOTOX; LC_{50} (mortality) 10-d; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.
Zooplankton	*Daphnia* sp.	--	0.04	Chapman *et al.* 1980	From Suter and Tsao (1996); lowest chronic value, life-cycle tests; used as TRV.
Predatory Fish	*Oncorhynchus mykiss*	--	0.06	Spehar 1976	From Suter and Tsao (1996); lowest chronic test EC_{20}; used as TRV.
Forage Fish	*Pimephales promelas*	0.238	0.06	Norberg and Mount 1985	From U.S. EPA ECOTOX; LC_{50} (mor) 7-d; derived TRV using a factor of 4 based on an empirical relationship between a chronic LC_{50} and an EC_{20}.

Notes:
LC_{50} Lethal concentration that results in mortality to 50% of population in short-term acute exposure tests.
EC_{50} Effects concentration that inhibits the growth rate on reproductive success of species in long-term chronic exposure tests.
TRV Toxicological Reference Value – Inhibitory concentration (EC_{20} value) that affects 20% of study population.

Table 5.2 Summary of Aquatic Toxicological Reference Values

COPC	Aquatic TRV (mg/L)					
	Aquatic Plants	Phytoplankton	Benthic Invertebrates	Zooplankton	Predator Fish	Forage Fish
Antimony	-	0.24	2.6	1.35	4	2.31
Arsenic	0.25	0.02	0.32	0.91	0.14	0.12
Cadmium	3	0.003	0.12	0.00075	0.002	0.009
Chromium	0.002	-	-	0.006	0.073	-
Cobalt	-	0.22	1.6	0.005	0.12	0.2
Copper	0.12	0.004	0.08	0.0041	0.0069	0.0077
Iron	-	-	-	1.48	7.5	0.6
Lead	145.2	0.63	0.019	0.02	0.022	0.42
Manganese	12.4	37.1	46	1.8	0.73	2.06
Mercury	0.005	-	-	0.00087	-	0.00087
Molybdenum	-	5	14.5	0.45	0.2	15
Nickel	0.18	0.03	0.86	0.06	0.06	0.29
Selenium	0.68	0.19	0.18	0.025	0.05	0.15
Silver	-	-	-	0.00058	0.00092	0.001
Strontium	-	150	10	42	9.3	2.13
Uranium	2.96	0.011	0.82	0.011	0.62	0.16
Vanadium	-	0.9	0.024	1.9	0.04	0.04
Zinc	8.64	0.04	0.283	0.04	0.06	0.06

Notes: '-' No aquatic TRV available

5.1.1.2 Sediment Quality

The potential ecological effects of sediment exposure at the historic Keno Hill Mine site were addressed in part through the examination of potential effects on benthic invertebrates. In contrast to the approach outlined above to assess the risks to aquatic species from exposure to COPC in the water column, the sediment toxicity evaluation involved comparison of measured levels of COPC in sediments to sediment toxicity benchmarks reported in the literature.

The CCME (2011) guidelines provide what are designated Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs). In narrative description, an ISQG represents the concentration below which adverse biological effects are expected to occur rarely (i.e., an ISQG represents the upper limit of the range of sediment COPC concentrations dominated by no effects data). A PEL defines the level above which adverse effects are expected to occur frequently (i.e., the PEL represents the lower limit of the range of COPC concentrations that are usually or always associated with adverse biological effects). The CCME acknowledge the associative basis of the guidelines and acknowledges that the use of ISQGs in exclusion of other information (such as background concentrations of naturally occurring substances and biological tests) can lead to erroneous conclusions.

The sediment toxicity benchmarks from Thompson *et al*. (2005) were developed for mining industry applications in northern Saskatchewan using data collected from northern Saskatchewan and Ontario. The Screening Level Concentration (SLC) approach was used to derive Lowest Effect Level (LEL) and Severe Effect Level (SEL) concentrations for nine metals and metalloids (arsenic, chromium, copper, lead, molybdenum, nickel, selenium, uranium and vanadium). The benchmark values reported by these authors are seen to cover a much wider range than those proposed by the CCME.

As indicated by the CCME (2001), *"The PEL is recommended as an additional sediment quality assessment tool that can be useful in identifying sediments in which adverse biological effects are more likely to occur."* Therefore, The PEL values from the CCME and the SEL values from Thompson et al. (2005) were used in this assessment to identify whether adverse biological effects on sediment dwelling populations are likely to occur. The sediment toxicity benchmarks used in this assessment are provided in Table 5.3, from which it can be seen that, where several toxicity benchmarks exist for a particular metal, there is a range of data for possible effects. Sediment toxicity benchmarks are not avialable for all COPC, and only those COPC with benchmarks are included in the table. Given the differences between the PEL and SEL values in Table 5.3 and the uncertainties associated with sediment toxicity evaluations, it is important to note that an exceedance of any of these benchmarks does not mean that an adverse effect would be observed; rather it means that further investigation or weight-of-evidence is necessary to determine an effect.

Table 5.3 Sediment Quality Toxicity Benchmarks

COPC	CCME 2011		Thompson *et al*. 2005	
	ISQG	PEL	LEL	SEL
Arsenic	5.9	17	9.8	346.4
Cadmium	0.6	3.5	-	-
Chromium	37.3	90	47.6	115.4
Copper	35.7	197	22.2	268.8
Lead	35	91.3	36.7	412.4
Mercury	0.17	0.486	-	-
Molybdenum	-	-	13.8	1238.5
Nickel	-	-	23.4	484
Selenium	-	-	1.9	16.1
Uranium	-	-	104.4	5874.1
Vanadium	-	-	35.2	160
Zinc	123	315	-	-

Notes:
No sediment toxicity data for antimony, cobalt, iron, manganese, silver, strontium
'-' No sediment TRV available
ISQG - Interim Sediment Quality Guideline PEL - Probable Effect Level
LEL - Lowest Effect Level SEL - Severe Effect Level

5.1.2 Terrestrial Wildlife Toxicity Evaluation

Databases of information are available that contain TRVs for specific receptors. In general, these focus on agricultural animals and common laboratory species, but may encompass a range of species including some wildlife. For this assessment, a report produced by Sample *et al*. (1996) from the Oak Ridge National Laboratory (ORNL) was used as the primary data source. Sample *et al.* (1996) examined data from different studies and selected an appropriate toxicity value based on studies in which reproductive and developmental endpoints were considered (endpoints that may be directly related to potential population-level effects), multiple exposure levels were investigated, and the reported results were evaluated statistically to identify any significant differences from control values. In the absence of toxicity data for most of the terrestrial animal receptors, data for laboratory animals (usually mice and rats) are used. For avian receptors, the test species are generally ducks or chicks.

When values were not available from Sample *et al.* (1996), studies reported in the U.S. EPA Ecological Soil Screening Level (Eco-SSL) documents (various years) were used to derive geometric means of Lowest Observable Adverse Effects Levels (LOAELs) and No Observable Adverse Effects Levels (NOAELs) reported for the same species for growth and reproduction endpoints. The accompanying LOAEL of the lowest NOAEL was considered to be the TRV. The LOAELs were chosen for this assessment based on the consideration that all pathways of exposure were taken into account for the receptors, since bioavailability was not considered (i.e., it was assumed that 100% of the COPC intake was dissolved in the gut of the species and taken into the body), and based on the fact that the LOAEL is a determination of whether an effect will occur.

The test species, chemical form, study duration, rationale and toxicological endpoint for the TRVs are presented in Table 5.4 for mammals and Table 5.5 for birds. The TRVs are summarized in Table 5.6.

Table 5.4 Summary of Toxicological Reference Values from Laboratory Animal Studies

COPC	**Antimony**	**Arsenic**	**Barium**	**Cadmium**	**Chromium**	**Cobalt**
Source of Values	Sample *et al*. 1996	Sample *et al*. 1996	Sample *et al*. 1996	U.S. EPA 2005a	Sample *et al.* 1996	U.S. EPA 2005b
Original Reference	Schroeder *et al.* 1968	Schroeder and Mitchener 1971	Borzelleca *et al.* 1988	Doyle *et al.* (1974)	MacKenzie *et al.* 1958	Nation *et al.* 1983; Domingo *et al.* 1985; Corrier *et al.* 1985; Mollenhauer *et al.* 1985; Chetty *et al.* 1979; Paternain *et al.* 1988; Derr *et al.* 1970
Chemical Species	Antimony potassium tartrate	Arsenite	Barium chloride	Cadmium Chloride	Cr^{+6} as $K_2Cr_2O_4$	Various
Test Species	Mouse	Mouse	Rat	Sheep	Rat	Rat
Body Weight (g)	30	30	350	Not reported	350	Various
Study Duration	lifetime (>1 yr)	3 generations (>1 yr)	10 days	163 days	1 year	Various (28 days - 98 days)
Endpoint	Lifespan, longevity	Reproduction	Mortality	Growth and body weight	Body weight and food consumption	Growth and reproduction
Comments	The study was carried out during a critical life stage and is considered to be chronic exposure.	The study was carried out during a critical life stage and is considered to be chronic exposure.	The study was carried out over a period of less than 10 weeks and is considered to be subchronic exposure	The study was carried out during a critical life stage and is considered to be chronic exposure	The study carried out during a critical life stage and is considered to be chronic exposure.	The studies were carried out on rats at various life stages (from gestation through to mature adult) and were considered to be chronic exposure
Logic	Median lifespan was reduced among female mice exposed to the 5 ppm dose level; this dose was considered to be a chronic LOAEL. NOAEL derived by applying an uncertainty factor of 0.1 to the LOAEL.	Mice displayed declining litter sizes with each successive generation at a dose of 1.26 mg/(kg-d) and thus this dose was considered to be a chronic LOAEL.	Exposure of rats to 300 mg/(kg-d) for 10 days resulted in 30% mortality in female rats; no adverse effects observed at any of the 3 other dose levels	The study was conducted during the juvenile life stage period in which the male lambs were four months old. The rate of ingestion was 1.99 kg/day and the route of exposure was food.	No significant differences were observed at any dose level studied and the study considered exposure over 1 year, the maximum dose was considered to be a chronic NOAEL.	For the species of interest, the lowest NOAEL of 5.22 mg/kg/day and the accompanying LOAEL of 13.39 mg/kg/day were considered based on the geometric mean of all values obtained from different tests.
NOAEL (mg/kg/d)	**0.125**	**-**	**-**	**0.45**	**3.28**	**5.22**
LOAEL (mg/kg/d)	**1.25**	**1.26**	**19.8**	**0.91**	**-**	**13.39**

Table 5.4 Summary of Toxicological Reference Values from Laboratory Animal Studies (Cont'd)

COPC	Copper	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium
Source of Values	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996
Original Reference	Aulerich *et al.* 1982	Azar *et al.* 1973	Laskey *et al.* 1982	Aulerich *et al.* 1974	Schroeder and Mitchener 1971	Ambrose *et al.* 1976	Rosenfeld and Beath 1954
Chemical Species	Copper sulphate	Lead acetate	Manganese oxide	Mercuric chloride ($HgCl_2$: 73.9% Hg)	Molybdate	Nickel sulphate hexahydrate	Potassium selenate
Test Species	Mink	Rat	Rat	Mink	Mouse	Rat	Rat
Body Weight (g)	1000	350	350	1000	30	350	350
Study Duration	357 days	3 generations (>1 yr)	From gestation to 224 days	6 months	3 generations (>1 yr)	3 generations (>1 yr)	1 year through 2 generations
Endpoint	Reproduction	Reproduction	Reproduction	Reproduction	Reproduction	Reproduction	Reproduction
Comments	The study was carried out during a critical life stage and is considered to be chronic exposure.	The study was carried out during a critical life stage and is considered to be chronic exposure.	The study was carried out during a critical life stage and is considered to be chronic exposure	The study was carried out during a critical life stage and is considered to be chronic exposure.	The study was carried out during a critical life stage and is considered to be chronic exposure.	The study was carried out during a critical life stage and is considered to be chronic exposure.	The study was carried out during a critical life stage and is considered to be chronic exposure.
Logic	The survival of kits at 25 ppm was actually higher than the controls and this level was taken to be the NOAEL. At 50 ppm the percentage mortality in kits was increased and this was considered to be the LOAEL.	None of the lead exposure levels affected the pregnancy rate, live birth rate or other reproductive indices. But, 1000 ppm exposure gave reduced offspring weight and produced kidney damage in young - LOAEL. NOAEL of 100ppm	Decreased pregnancy percentage and fertility noted at the highest dose of 3550 ppm, while other reproductive parameters were not affected. This was taken as the LOAEL. No effects seen at 1100 ppm or lower and therefore NOAEL.	While kit weight was somewhat reduced (9% relative to controls), fertility, and kit survival were not reduced. Because the study considered exposure through reproduction, the 7.39 ppm Hg dose was considered to be a chronic NOAEL.	Mice displayed reduced reproductive success with a high incidence of runts.	No adverse effects observed over 3 generations at a concentration of 500 ppm. Therefore this value considered to be a NOAEL. At 1000 ppm, reduced offspring body weights observed. This value is the LOAEL.	No adverse effects on reproduction at a concentration of 1.5 mg/L. This value is the NOAEL. At 2.5 mg/L the number of second-generation young was reduced by 50% among females. This value is the LOAEL.
NOAEL (mg/kg/d)	**11.7**	**8**	**88**	**1.0**	**0.26**	**40**	**0.2**
LOAEL (mg/kg/d)	**15.14**	**80**	**284**	**-**	**2.6**	**80**	**0.33**

Table 5.4 Summary of Toxicological Reference Values from Laboratory Animal Studies (Cont'd)

COPC	Silver	Strontium	Thallium	Uranium	Vanadium	Zinc	Zirconium
Source of Values	ATSDR (2011, last updated 1990)	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	U.S. EPA 2007	Sample *et al.* 1996
Original Reference	Walker 1971	Skoryna 1981	Formigli *et al*. 1986	Paternain *et al.* 1989	Domingo *et al.* 1986	Hill *et al*. 1983; Brink *et al*. 1959;, Hsu *et al*. 1975	Schroeder *et al.* 1968
Chemical Species	Silver nitrate	Strontium chloride	Thallium sulphate	Uranyl acetate	Sodium metavanadate	Zinc oxide	Zirconium sulfate
Test Species	Rat	Rat	Rat	Mouse	Rat	Pig	Mouse
Body Weight (g)	350	350	350	28	260	Various	30
Study Duration	14 days	3 years	60 days	60 days prior to gestation, gestation, delivery and lactation	60 days prior to gestation as well as gestation, delivery and lactation	Various (42 days - 12 months)	lifetime (> 1 year)
Endpoint	Mortality	Body weight and bone changes	Reproduction	Reproduction	Reproduction	Growth and reproduction	Lifespan, longevity
Comments	This study was based on short term exposure	Because the study considered exposure over three years the endpoint is considered to be chronic.	The study was not carried out during a critical life stage and is considered to be subchronic exposure	The study was carried out during a critical life stage and is considered to be chronic exposure.	The study was carried out during a critical life stage and is considered to be chronic exposure.	The studies were carried out over various life stages and were considered to be chronic exposure.	The study was carried out over a period greater than 1 year and is considered to be chronic exposure
Logic	A 2-week study on rats exposed to silver nitrate in their drinking water resulted in the death of 3 out of 12 test animals. Test animals were observed to drastically decrease their drinking water intake and appeared listless and poorly groomed. Lethality was not observed in the lower dose group.	No adverse effects were observed for any Strontium dosage level.	Reduced sperm motility was observed at 10 ppm thallium and was considered a subchronic LOAEL. Converted to subchronic NOAEL with an uncertainty factor of 0.01.	No adverse effects observed at 3.1 mg U/kg-d, therefore considered a NOAEL. At 6.1 mg U/kg-d significant differences in mortality, size and weight of offspring, etc., were observed.	Significant differences noted in reproductive parameters such as litter size, number of dead per litter, weight of offspring etc. at all dose levels. Lowest dose of 2.1 mg/(kg-d) considered to be a chronic LOAEL.	For the species of interest, the lowest NOAEL of 15.4 mg/kg/day and the accompanying LOAEL of 90 mg/kg/day were considered based on the geometric mean of all values obtained from different tests.	No significant treatment effects were observed at the 5 ppm dose level in water
NOAEL (mg/kg/d)	**181.2**	**263**	**0.0074**	**3.07**	**-**	**15.4**	**1.74**
LOAEL (mg/kg/d)	**362.4**	**-**	**0.074**	**6.13**	**2.1**	**90**	**-**

Table 5.5 Summary of Toxicological Reference Values from Laboratory Bird Studies

COPC	Antimony	Arsenic	Barium	Cadmium	Chromium	Cobalt
Source of Values	No toxicity data available	Sample *et al.* 1996	Sample *et al.* 1996	U.S. EPA 2005a	Sample *et al.* 1996	U.S. EPA 2005b
Original Reference		USFWS 1964	Johnson *et al.* 1960	Various [a]	Haseltine *et al.*, unpubl. data	Various [b]
Chemical Species		Arsenite (As^{3+})	Barium hydroxide	Various	Cr^{+3} as $CrK(SO_4)_2$	Various
Test Species		mallard duck	1 day old chicks	Chicken	black duck	Chicken
Body Weight (g)		1000	121	Various	1250	Various
Study Duration		128 d (>10 wks)	4 weeks	Various (2 weeks - 12 months)	10 months	Various (2 weeks - 5 weeks)
Endpoint		Mortality	Mortality	Growth and reproduction	Reproduction	Growth and reproduction
Comments		The study was carried out over a period greater than 10 weeks and is considered to be chronic exposure.	The study was carried out over a period of less than 10 weeks and is considered to be subchronic exposure.	Various life stages were considered, from juvenile to laying bird and were considered to be chronic exposure.	The study was carried out over a period greater than 10 weeks and is considered to be chronic exposure.	The studies were carried out for critical life stages (juvenile and immature) and were considered to be subchronic exposure.
Logic		Over 128 days, at a dose of 100 ppm sodium arsenite, the ducks experienced no mortality, and thus this value is considered to be the NOAEL. A dose of 250 ppm resulted in 12% mortality and is considered to be a chronic LOAEL.	Exposures up to 2000 ppm produced no mortality and this was considered a subchronic NOAEL. Chicks in the 4000 to 32,000 ppm groups experienced 5% to 100% mortality and this was a subchronic LOAEL. Both were converted to chronic values with an uncertainty factor of 0.1	For the species of interest, the lowest NOAEL of 0.97 mg/kg/day and the accompanying LOAEL of 4.38 mg/kg/day were considered based on the geometric mean of all values obtained from different tests.	While duckling survival was reduced at the 50 ppm dose level, no significant differences were observed at the 10 ppm Cr^{+3} dose level. The dose 50 ppm dose was considered to be a chronic LOAEL and the 10 ppm dose was considered to be a chronic NOAEL.	For the species of interest, the lowest NOAEL of 4.09 mg/kg/day and the accompanying LOAEL of 14.13 mg/kg/day were considered based on the geometric mean of all values obtained from different tests.
NOAEL (mg/kg/d)		**5.135**	**20.8**	**0.97**	**1**	**4.09**
LOAEL (mg/kg/d)		**12.84**	**41.7**	**4.38**	**5**	**14.13**

Notes:

a Bafundo *et al.* 1984; Bokori *et al*. 1995, 1996; Fadil and Magid 1996; Freeland and Cousins 1973; Hill 1980, 1979a, 1974a, 1974b; Leach *et al.* 1979; Lefevre *et al.* 1982; Pritzl *et al.* 1974; Rama and Planas 1981; Sell 1975

b Brown and Southern 1985; Diaz *et al.* 1994a, 1994b; Hill 1979b, 1974a; Ling and Leach 1979; Southern and Baker 1981

Table 5.5 Summary of Toxicological Reference Values from Laboratory Bird Studies (Cont'd)

COPC	Copper	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium
Source of Values	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996	Sample *et al.* 1996
Original Reference	Mehring *et al*. 1960	Edens *et al.* 1976	Laskey and Edens 1985	Hill and Schaffner 1976	Lepore and Miller 1965	Cain and Pafford 1981	Heinz *et al*. 1987
Chemical Species	Copper oxide	Lead acetate	Manganese oxide	Mercuric chloride	Sodium molybdate	Nickel sulphate	Sodium selenite
Test Species	Chicks (1-day old)	Japanese quail	Japanese quail	Japanese quail	Chicken	Mallard duckling	Mallard duck
Body Weight (g)	534	150	72	150	1500	782	1000
Study Duration	10 weeks	12 weeks	75 days	1 year	21 days	90 days	78 days
Endpoint	Growth, mortality	Reproduction	Growth, aggressive behaviour	Reproduction	Reproduction	Mortality, growth, behaviour	Reproduction
Comments	The 10-week study was considered to be chronic exposure.	The study was carried out over a period greater than 10 weeks and is considered to be chronic exposure.	The study was carried out over a period greater than 10 weeks and is considered to be chronic exposure.	The study was carried out through the reproductive cycle and is considered to be chronic exposure.	The study was carried out through the reproductive cycle and is considered to be chronic exposure.	The study was carried out over a period greater than 10 weeks and is considered to be chronic exposure.	The study was carried out through the reproductive cycle and is considered to be chronic exposure.
Logic	Consumption of copper up to 570 ppm had no effect on the growth of chicks and was considered to be the NOAEL. At 749 ppm there was a 30% reduction in growth and a 15% mortality. This level is considered to be the LOAEL.	Reproduction not impaired by the 10 ppm dose, but egg hatching success reduced at the 100 ppm dose. Therefore 10 and 100 ppm are considered the NOAEL and LOAEL, respectively.	The study noted no effect on growth in birds fed 5056 ppm manganese in the diet. Aggressive behaviour was noted to be reduced by 25 to 50% relative to controls but this was not considered an adverse effect. NOAEL was taken as 977 mg/kg-d.	While egg production increased with increasing Hg dose, fertility and hatchability decreased. Adverse effects of Hg were evident at the 8 mg Hg/kg dose. Because the study considered exposure during reproduction, the 4 and 8 mg Hg/kg dose levels were considered to be chronic NOAELs and LOAELs, respectively.	Embryonic viability was reduced to zero at the lowest dose of 500 ppm and this was considered to be a LOAEL.	Consumption of up to 77.4 ppm Ni in diet did not increase mortality or decrease growth and is thus the NOAEL. At 1069 ppm there was a 70% mortality which is considered to be a LOAEL.	Consumption of 1, 5 and 10 ppm had no effect on weight and survival of adults but 10 and 25 ppm resulted in significantly larger frequency of lethally deformed embryos as compared to 1 or 5 ppm. Therefore 10 ppm is the LOAEL and 5 ppm is the NOAEL.
NOAEL (mg/kg/d)	**47**	**1.13**	**977**	**0.45**	**-**	**77.4**	**0.5**
LOAEL (mg/kg/d)	**61.7**	**11.3**	**-**	**0.9**	**35.3**	**107**	**1**

Table 5.5 Summary of Toxicological Reference Values from Laboratory Bird Studies (Cont'd)

COPC	Silver	Strontium	Thallium	Uranium	Vanadium	Zinc	Zirconium
Source of Values	No toxicity data available	No toxicity data available	No toxicity data available	Sample *et al.* 1996	Sample *et al.* 1996	U.S. EPA 2007	No toxicity data available
Original Reference				Haseltine and Sileo 1983	White and Dieter 1978	Hamilton *et al.* 1981, 1979	
Chemical Species				Depleted metallic uranium	Vanadyl sulphate	Zinc carbonate	
Test Species				Black duck	Mallard duck	Japanese quail	
Body Weight (g)				1250	1170	23	
Study Duration				6 weeks	12 weeks	7 days - 14 days	
Endpoint				Mortality, body weight, liver and kidney effects	Mortality, body weight, blood chemistry	Blood effects, growth, mortality	
Comments				The study was less than 10 weeks and only considered to be subchronic exposure.	The study was carried out over longer than 10 weeks and was considered to be chronic exposure.	The studies were carried out during a critical life stage (juvenile) and were considered to be subchronic exposure.	
Logic				No effects observed at highest dose level of 160 mg U. Therefore considered a subchronic NOAEL. 10 for conversion from subchronic to chronic exposure.	No effects observed at any dose level. The maximum dose of 11.4 mg/(kg-d) considered to be a chronic NOAEL.	For the species of interest, the lowest NOAEL of 61.3 mg/kg/day and the accompanying LOAEL of 123 mg/kg/day were considered based on the geometric mean of all values obtained from different tests.	
NOAEL (mg/kg/d)				**16**	**11.4**	**61.3**	
LOAEL (mg/kg/d)				**-**	**-**	**123**	

Table 5.6 Summary of LOAEL Toxicological Reference Values for Terrestrial Ecological Receptors

COPC (mg/(kg-d))	Bear	Beaver	Caribou	Fox	Grouse	Hare	Mallard	Marmot	Merganser	Mink	Moose	Scaup	Sheep	Wolf
Antimony	1.25	1.25	1.25	1.25	N/A	1.25	N/A	1.25	N/A	1.25	1.25	N/A	1.25	1.25
Arsenic	1.26	1.26	1.26	1.26	12.84	1.26	12.84	1.26	12.84	1.26	1.26	12.84	1.26	1.26
Barium	19.8	19.8	19.8	19.8	41.7	19.8	41.7	19.8	41.7	19.8	19.8	41.7	19.8	19.8
Cadmium	0.91	0.91	0.91	0.91	4.38	0.91	4.38	0.91	4.38	0.91	0.91	4.38	0.91	0.91
Chromium	3.28 [(a)]	3.28 [(a)]	3.28 [(a)]	3.28 [(a)]	5	3.28 [(a)]	5	3.28 [(a)]	5	3.28 [(a)]	3.28 [(a)]	5	3.28 [(a)]	3.28 [(a)]
Cobalt	13.39	13.39	13.39	13.39	14.13	13.39	14.13	13.39	14.13	13.39	13.39	14.13	13.39	13.39
Copper	15.14	15.14	15.14	15.14	61.7	15.14	61.7	15.14	61.7	15.14	15.14	61.7	15.14	15.14
Lead	80	80	80	80	11.3	80	11.3	80	11.3	80	80	11.3	80	80
Manganese	284	284	284	284	977 [(a)]	284	977 [(a)]	284	977 [(a)]	284	284	977 [(a)]	284	284
Mercury	1 [(a)]	1 [(a)]	1 [(a)]	1 [(a)]	0.9	1 [(a)]	0.9	1 [(a)]	0.9	1 [(a)]	1 [(a)]	0.9	1 [(a)]	1 [(a)]
Molybdenum	2.6	2.6	2.6	2.6	35.3	2.6	35.3	2.6	35.3	2.6	2.6	35.3	2.6	2.6
Nickel	80	80	80	80	107	80	107	80	107	80	80	107	80	80
Selenium	0.33	0.33	0.33	0.33	1	0.33	1	0.33	1	0.33	0.33	1	0.33	0.33
Silver	362.4	362.4	362.4	362.4	N/A	362.4	N/A	362.4	N/A	362.4	362.4	N/A	362.4	362.4
Strontium	263 [(a)]	263 [(a)]	263 [(a)]	263 [(a)]	N/A	263 [(a)]	N/A	263 [(a)]	N/A	263 [(a)]	263 [(a)]	N/A	263 [(a)]	263 [(a)]
Thallium	0.074	0.074	0.074	0.074	N/A	0.074	N/A	0.074	N/A	0.074	0.074	N/A	0.074	0.074
Uranium	6.13	6.13	6.13	6.13	16 [(a)]	6.13	16 [(a)]	6.13	16 [(a)]	6.13	6.13	16 [(a)]	6.13	6.13
Vanadium	2.1	2.1	2.1	2.1	11.4 [(a)]	2.1	11.4 [(a)]	2.1	11.4 [(a)]	2.1	2.1	11.4 [(a)]	2.1	2.1
Zinc	90	90	90	90	123	90	123	90	123	90	90	123	90	90
Zirconium	1.74 [(a)]	1.74 [(a)]	1.74 [(a)]	1.74 [(a)]	N/A	1.74 [(a)]	N/A	1.74 [(a)]	N/A	1.74 [(a)]	1.74 [(a)]	N/A	1.74 [(a)]	1.74 [(a)]

Notes:
N/A Toxicity data not available
a No LOAEL value; NOAEL used in lieu

5.2 HUMAN TOXICITY EVALUATION

Exposure of humans to COPC is conventionally assessed against TRVs. Toxicity is the potential of a constituent to cause some type of damage, either permanent or temporary, to the structure or functioning of any part of the body. The toxicity depends on the amount of the constituent taken into the body (generally termed the intake or dose) and the length of time a person is exposed. Every constituent has a specific dose and duration of exposure that is necessary to produce a toxic effect in humans. Toxicity assessments generally involve the evaluation of scientific studies, based either on laboratory animal tests or on workplace exposure investigations, by a number of experienced scientists in a wide range of scientific disciplines in order to determine the maximum dose that a human can be exposed to without having an adverse health effect. Levels that are likely to result in no appreciable risks or no measurable adverse effects are known as exposure limits.

There are several regulatory sources that report TRVs. Some of the most used sources include Health Canada, the U.S. EPA Integrated Risk Information System (IRIS) database, the Ontario Ministry of the Environment (MOE 2009), U.S. EPA health assessment reports (HEAST), U.S. EPA National Center for Environmental Assessment (NCEA), the World Health Organization (WHO), the California Environmental Protection Agency (CalEPA) and the Agency for Toxic Substances and Disease Registry (ATSDR). For this assessment, TRVs provided by Health Canada (2009c) were preferentially selected for evaluation of the potential adverse effects on humans. Details on the derivation of these values are provided in the accompanying appendix (Health Canada 2009d). The U.S. EPA IRIS database (U.S. EPA 2011) is another major source for TRVs and thus was used to infill data gaps from Health Canada (2009c). When data were not available in these two sources, then data were obtained from other sources as available.

Table 5.7 provides a summary of the selected TRVs. Oral, dermal and inhalation pathways are considered in this assessment; however, there are no dermal TRVs and it is a generally accepted practice in risk assessments to use the oral TRV to assess dermal exposure. The value, toxicological endpoint and reference for each TRV are provided in the table. Further details on the selection of each TRV are provided in the following sections.

5.2.1 Non Carcinogenic TRVs

For many non-carcinogenic effects, protective biological mechanisms must be overcome before an adverse effect from exposure to the chemical is manifested. This is known as a "threshold" concept. Non-carcinogens are often referred to as "systemic toxicants" because of their effects on the function of various organ systems. For this reason, scientists generally agree that there is a level (threshold) below which no adverse effects would be measurable or expected to occur.

These toxicological reference values are generally referred to as reference doses (RfDs) or reference concentrations (RfCs), tolerable daily intakes (TDIs), or acceptable daily intakes (ADIs), and are generally derived by regulatory agencies such as Health Canada and the United States Environmental Protection Agency (U.S. EPA). These TRVs are usually expressed as the quantity of a chemical per unit body weight per unit time (mg/(kg-day)), but RfCs are expressed as a maximum permissible concentration in air (mg/m^3). The values have generally been derived for sensitive individuals in the public using the most sensitive endpoint available. Additionally, these factors involve the incorporation of "safety factors" by regulatory agencies to provide additional protection for members of the public.

The COPC considered to be non-carcinogenic or non-classifiable with respect to human carcinogenicity, indicating that there are no human or animal data to indicate that they are carcinogens, include antimony, cobalt, copper, lead, manganese, molybdenum, selenium, silver, strontium, uranium, vanadium and zinc. The rationale for the selection of the non-carcinogenic TRVs for all COPC is discussed below.

Antimony

In its elemental form, antimony is a silvery white metal that breaks easily and is found naturally in the earth's crust. Antimony has two oxidation states, (+3) and (+5), although it is usually found as a sulphide or oxide.

Human studies show that antimony is primarily excreted in urine, and that feces and other routes are secondary elimination pathways. Excretion pathways will vary according to different exposure pathways, animal species and oxidation state of antimony. For example, trivalent antimony is excreted mainly *via* the feces, while pentavalent organic antimony is excreted mainly in the urine (Health Canada 1997).

Symptoms of acute oral and inhalation exposures to antimony include GI disorders, dehydration, muscular pain, shock, and kidney and urinary disorders. Dermal exposure to antimonials in humans can result in eczema and dermatitis (Stemmer 1976). Populations especially susceptible to antimonials may include individuals with existing medical conditions affecting the respiratory system, the cardiovascular systems, and the kidney because antimony toxicity is primarily manifested through these organ systems (ATSDR 2011, last updated 1992).

The U.S. EPA (2011, last updated 1991) provides an oral RfD of 0.0004 mg/(kg-d) for antimony, based on a LOAEL of 0.35 mg/(kg-d) from a chronic oral toxicity study where rats were administered potassium antimony tartrate in water. The toxicological endpoint was decreased longevity and blood glucose, and altered cholesterol levels. An uncertainty factor of 1000 was used: 10 to account for interspecies conversion; 10 to account for human variability; and 10 because a LOAEL was used to derive the RfD. The overall confidence in this RfD is reported to be low.

Health Canada (1997) provides an oral TDI of 0.0002 mg/(kg-d) derived from a NOAEL of 0.06 mg/(kg-d) from a 13-week rat study involving oral administration of potassium antimony tartrate *via* drinking water. An uncertainty factor of 300 was used: 10 to account for inter-species variability; 10 for human variability; and 3 for use of a short-term study to derive a chronic exposure limit. This value is not provided as a TRV in the most recent *Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical Specific Factors* (Health Canada 2009c); as such, the U.S. EPA IRIS RfD was used in this assessment as the TRV in favour of the Health Canada TDI.

Neither the IRIS database nor Health Canada provide inhalation RfCs for exposure to antimony; however, a value of 0.0002 mg/m^3 is provided in the 2008 HEAST report (U.S. EPA 2008). No details are provided on the derivation of this value. Nonetheless, this value was used as the inhalation TRV in this assessment for lack of other data. The MOE (2009) supports this value.

No exposure limits are provided for the potential carcinogenicity of antimony or antimonials. The U.S. EPA (2011) states that antimony has not yet undergone a complete evaluation and determination for evidence of human carcinogenic potential under the IRIS program.

Barium

Barium occurs in nature in many different forms. Two of the most common forms that are found as underground ore deposits are barium sulphate and barium carbonate. These compounds do not mix well with water and are therefore not generally found in high concentrations in drinking water. Other water-soluble forms such as barium chloride and barium hydroxide are not found commonly in nature, and therefore generally end up in drinking water only as a result of contamination from waste sites (ATSDR 2011, last updated 2007).

Health Canada (2009c) provides an oral TDI of 0.016 mg/(kg-d) for cardiovascular disease and increased blood pressure in humans exposed to barium in drinking water. A NOAEL of 7.3 mg/L was obtained from a cross-sectional epidemiological study, and was adjusted to a value of 0.16 mg/(kg-d) for average adult water intake and body weight. An uncertainty factor of 10 was applied to account for intraspecies variation.

The U.S. EPA (2011, last updated 2005) derived a less conservative oral RfD of 0.2 mg/kg-d, based on a two-year drinking water study in mice. The point of departure was the 95% lower confidence limit on the maximum likelihood estimate of the dose corresponding to a 5% extra risk.

In this assessment, the more conservative value of 0.016 mg/(kg-d) from Health Canada was used.

Cadmium

Environmental exposure to cadmium can occur via the diet and drinking water. Cadmium is transported in the blood and widely distributed in the body but accumulates primarily in the liver and kidneys (Goyer 1991). Cadmium is excreted primarily in the urine. Long-term exposure to cadmium primarily affects the kidneys, resulting in tubular proteinosis although other conditions such as "itai-itai" disease may involve the skeletal system.

Health Canada (2009c) provides an oral TDI of 0.001 mg/(kg-d) which was derived from data from an epidemiological study of occupationally exposed workers. A NOAEL of 2.5 µg Cd/g creatinine in urine was obtained which was associated with a chronic oral intake of 0.5 to 2.0 µg/kg-d. Therefore Health Canada maintained the provisional tolerable weekly intake of 7 µg/kg-w, which is equivalent to 1.0 µg/kg-d (0.001 mg/kg-d). This value was used as the TRV in this assessment.

Cadmium is considered to be carcinogenic *via* the inhalation pathway. The carcinogenic TRVs are discussed further in Section 5.2.2.

Chromium

Chromium (Cr) is an element of natural and anthropogenic origin. Naturally occurring chromium is found in rock, flora and fauna and volcanic dust and gases. Chromium is found in several different oxidation states, or forms, including the most common metallic chromium (Cr(0)), trivalent chromium (Cr(III)) and hexavalent chromium (Cr(VI)) compounds. Some chromium such as chromium (III) is naturally occurring, but chromium (VI) and (0) compounds are mostly of anthropogenic origin. Anthropogenic sources of chromium to the environment include fossil fuel combustion, iron and steel production, waste from the chemical industry and transportation-related sources.

Health Canada (2009c) provides an oral non-carcinogenic TDI of 0.001 mg/(kg-d) for total chromium, based on the Canadian Guidelines for Drinking Water Quality listed in Health Canada (1986). This corresponds to a maximum acceptable concentration (MAC) of 0.05 mg/L which converts to the TDI using the consumption rate of 1.5 L/d of water and a body weight of 70 kg. The health endpoint was related to hepatotoxicity, irritation or corrosion of the gastrointestinal tract and encephalitis. This value was used in the assessment.

Chromium is considered to be carcinogenic *via* the inhalation pathway. The carcinogenic TRVs are discussed further in Section 5.2.2.

Cobalt

In its elemental form, cobalt is a hard silvery-gray metal. Naturally occurring, cobalt has two valent states (+2 and +3) and is usually found in the environment combined with other elements such as oxygen, sulphur, and arsenic. Small amounts of these chemical compounds can be found in rocks, soil, plants, and animals. Cobalt is even found in water in dissolved or ionic form, typically in small amounts. The natural amount of cobalt present in soils and water is taken up by plants and bacteria to form Vitamin B_{12}., an essential in humans for the formation of red blood cells.

The absorption of cobalt and cobalt compounds *via* oral exposure has been well studied in literature. Gastrointestinal absorption in humans was found to vary considerably (18-97%) based upon the chemical species of cobalt, the amount administered, and the nutritional status of the subjects (ATSDR 2011, last updated 2004). Cobalt, a component of vitamin B_{12}, is an essential nutrient, and as a result is found in most body tissues including the liver, muscle, lung, lymph nodes, heart skin, bone, hair, stomach, brain, pancreatic juice, kidneys, plasma, and urinary bladder of non-exposed subjects, with the highest amount in the liver. Similar distribution is expected as a result of inhalation and oral exposure to impacted materials.

Fecal elimination was found to be the primary route of elimination in both human and animal studies following oral exposure. The amount eliminated was found to be dependent on the amount administered, the type of cobalt ingested, as well as the nutritional status of the subjects.

Oral exposure to cobalt in human and/or animal studies resulted in respiratory, cardiovascular, gastrointestinal, hematological, hepatic, renal, endocrine, dermal, ocular, hypothermic and body weight effects (ATSDR 2011, last updated 2004). In a study conducted by Berg and Burback (1972, as cited in ATSDR 2011), the cancer mortality and trace metal concentration was compared. The study found no correlation between cobalt concentration and cancer mortality associated with oral ingestion. As a result, oral exposure to cobalt is not considered to be carcinogenic.

Health Canada, the CalEPA and the U.S. EPA do not provide exposure limits for cobalt. The ATSDR (2011, last updated 2004) provides minimal risk levels (MRLs) for acute and intermediate duration exposure to cobalt, but does not provide MRLs for chronic exposure. The MOE (2009) provides an oral RfD of 0.001 mg/kg-d, modified from the intermediate duration MRL of 0.01 mg/(kg-d) for hematological effects from the ATSDR. The value from the MOE was selected in this assessment.

The ATSDR provides a chronic inhalation MRL of $1x10^{-4}$ mg/m^3, derived from a NOAEL of $5.3x10^{-3}$ mg/m^3 for pulmonary function effects in occupationally-exposed workers. The National Institute of Public Health and Environmental Protection (RIVM 2001) derived a value of $5x10^{-4}$

mg/m^3 from a LOAEL of 0.05 mg/m^3 for interstitial lung disease. This value is supported by the MOE (2009) and was used in this assessment.

Copper

Toxicity resulting from acute oral exposure to copper has been shown to occur but is quite rare because copper is a potent emetic. There is very limited data available on the effects of chronic oral exposure to copper. The liver has been demonstrated to be the sensitive target organ for copper toxicity. Rat studies suggest that kidney damage is possible at doses causing liver damage, although kidney damage may be associated with a latency period (ATSDR 2011, last updated 2004).

Dermal exposure to copper has been shown to result in pruritic and contact allergic dermatitis, and eye irritation (ATSDR 2011, last updated 2004; Askergren and Mellgren 1975).

Health Canada (2009c) provides oral RfDs for copper based on various age groupings. The TRVs for toddlers, children, teens and adults are 0.091, 0.111, 0.126 and 0.141 mg/kg-d, respectively (Health Canada 2009c, 2009d). This is based on epidemiological studies and the endpoint is related to hepatotoxicity and gastrointestinal effects. These values were used in the assessment.

Lead

The most sensitive target organs for lead are thought to be the nervous system, the hematopoetic system, and the cardiovascular system. Toxic effects of lead are also manifested through the kidneys, immunological and reproductive systems (ATSDR 2011, last updated 2007).

Lead has been designated as a probable human carcinogen, but currently its critical effect endpoint is considered to be neurological effects in children. Chronic exposure to lead can also lead to nephropathy in adults and children, but has not been detected at blood levels below 40 µg/dL (Health Canada 1992).

The Joint FAO/WHO Expert Committee on Food Additives (JECFA) established a provisional tolerable weekly intake (pTWI) of 0.025 mg/kg in 1986 for lead exposure to children, and has reconfirmed this value (WHO 1987). This is equivalent to an RfD of 0.0035 mg/kg-d. This exposure limit is prescribed based on the knowledge that lead is a cumulative toxin and that any increase in lead body burdens should be avoided. The NOAEL of 0.003 to 0.004 mg/(kg-d) is taken from metabolic studies in infants, and was not associated with any increases in blood lead levels or lead body burdens. A LOAEL of 0.005 mg/(kg-d) was identified to be associated with body retention of lead. An uncertainty factor of 2 was selected because the endpoint and receptor selected were conservative, and because the studies selected were of good quality.

Health Canada (2009c) provides an oral TDI of 0.0036 mg/(kg-d) based on the same studies with an endpoint of a significant increase in the blood lead concentrations in infants. This value was used in the assessment.

Manganese

Manganese is essential for normal physiologic functioning in all animal species. Several diseases in humans have been associated with deficiencies and excesses of manganese intakes. Thus, any quantitative risk assessment for manganese must take into account aspects of both the essentiality and the toxicity of manganese. In humans, there is a lot of information about the range of essentiality for manganese. Additionally, there are many reports of toxicity to humans exposed to manganese by inhalation; however, very little is known about the oral toxicity of manganese. Therefore, the toxicity information on oral exposures is related to safe dietary intakes.

The World Health Organization (WHO 1973) reported the average daily consumption of manganese in diets to range from 2.0-8.8 mg Mn/d. Higher manganese intakes are associated with diets high in whole-grain cereals, nuts, green leafy vegetables, and tea. From manganese balance studies, the WHO concluded that 2-3 mg/d is adequate for adults and 8-9 mg/d is "perfectly safe."

The U.S. EPA IRIS database (2011, last updated 1996) provides an oral RfD of 0.14 mg/(kg-d) based on potential central nervous system effects based on human chronic ingestion data. The assessment focuses on what is known to be a safe oral intake of manganese for the general human population, which was taken as 10 mg/d. As the information used to determine the RfD was taken from many large populations consuming normal diets over an extended period of time with no adverse health effects an uncertainty factor of 1 was used.

Health Canada (2009c, 2009d) derived TRVs based on different life stages. The TRVs for toddlers, children, teens and adults are 0.136, 0.122, 0.142 and 0.156 mg/kg-d, respectively, based on epidemiological studies which result in Parkinsonian-like neurotoxicity. These values were used in the assessment.

Mercury

Mercury occurs naturally in the environment and exists as metallic (elemental) mercury, inorganic mercury, and organic mercury. At room temperature, metallic mercury is semi-volatile and will evaporate to form mercury vapours that are colourless and odourless. Of the forms found in the environment, methylmercury (an organic form) is of particular concern because it can build up in certain edible freshwater and saltwater fish and marine mammals (ATSDR 2011, last updated 1999).

The U.S. EPA (2011, last updated 1995) provides an oral RfD of 0.0003 mg/(kg-d) for exposure to mercuric chloride, based on a review of studies of subchronic feeding and subcutaneous exposure to rats in which the critical effect was autoimmune effects. A LOAEL of 0.226 mg/(kg-d) was determined. The RfD was derived by dividing the LOAEL by an uncertainty factor of 1000: 10 for extrapolation of a NOAEL to a LOAEL; 10 for the use of subchronic studies; and 10 for interspecies and human variability. The overall confidence in the RfD is reported to be high.

Health Canada (2009c) also derived an oral TDI of 0.0003 mg/(kg-d) for exposure to inorganic mercury, derived from a LOAEL of 0.3 mg/(kg-d) for nephrotoxicity in rats. This value was used in the assessment.

The U.S. EPA (2011, last updated 1995) also provides an inhalation RfC. A value of 0.0003 mg/m^3 was derived from a duration-adjusted LOAEL of 0.009 mg/m^3 for motor control, increases in memory disturbances, and slight evidence of autonomic dysfunction in occupationally exposed workers. This value was used in the assessment.

Molybdenum

Molybdenum occurs naturally in the environment in various ores. Silvery white in colour, metallic molybdenum exhibits properties that have that have allowed it to be used in electronic parts, induction heating elements, and electrodes. Molybdenite (MoS_2), the most commonly mined ore, is converted to molybdenum trioxide (MoO_3) for use in ferro- and manganese alloys, chemicals, catalysts, ceramics, and pigments.

Molybdenum is a considered an essential trace element in the human body, and it functions as an electron transport agent for various enzyme reactions within the body including xanthine oxidase, an enzyme involved in the breakdown of purines to uric acid.

The U.S. EPA (2011, last updated 1993) provides an oral RfD of 0.005 mg/kg-d, based on a LOAEL of 0.14 mg/(kg-d) for increased uric acid levels in a human lifetime dietary exposure study by Koval'skiy *et al*. (1961).

Health Canada derived TRVs for molybdenum based on different life stages. The TRVs are 0.023 mg/(kg-d) for toddlers and children, 0.027 mg/(kg-d) for teens, and 0.028 mg/(kg-d) for adults, based on reproductive effects in rats administered molybdenum in drinking water (Fungwe *et al*. 1990). The Health Canada values were used in this assessment as they are based on a more recent study than those derived by the U.S. EPA.

Nickel

The most common harmful health effect of nickel in humans is an allergic reaction. Approximately 10-20% of the population is sensitive to nickel. The most common reaction is a skin rash at the site of contact. Some sensitized people react when they consume food or water containing nickel or breathe dust containing it. Eating or drinking large amounts of nickel has been reported to affect the stomach, blood, liver, kidneys, and immune system in rats and mice, as well as their reproduction and development. Inhalation of nickel has been reported to cause carcinogenic effects; however, this pathway is not being considered in the risk assessment.

Health Canada (2009c) provides an oral TDI for nickel for soluble chloride and sulphate salts which has been used to develop the soil quality guideline for nickel. A value of 0.011 mg/(kg-d) was derived, based on a reproductive study in rats which resulted in a NOAEL of 1.1 mg/kg-d. The endpoint was post-implantation perinatal lethality. This value was used as the oral RfD in the assessment.

Health Canada (2009c) also provides an inhalation TRV for soluble and insoluble forms of nickel, for lung lesions in rats administered nickel for two years. The derived value was 2.0×10^{-5} mg/m^3 and was used in this assessment.

Nickel is considered to be carcinogenic *via* the inhalation pathway. The carcinogenic TRVs are discussed further in Section 5.2.2.

Selenium

Selenium is a naturally occurring element. Metallic gray to black in colour, pure selenium is often found combined with other substances in the environment such as sulfide mineral, oxygen or with silver, copper, lead and nickel minerals. Selenium and selenium compounds are readily absorbed from the human gastrointestinal tract.

The U.S. EPA (2011, last updated 1993) provides an oral RfD of 0.005 mg/kg-d, based on a NOAEL of 0.015 mg/(kg-d) from a study of clinical and biochemical signs of selenium intoxication in individuals living in an area of China with unusually high environmental concentrations of selenium (Yang and Zhou 1989). To derive the RfD, a factor of 3 was applied to account for human variability, and was considered appropriate because the individuals in the study were sensitive individuals drawn from the larger study population.

Health Canada (2009c) provides age-dependant TRVs for selenium of 0.0062 mg/(kg-d) for a toddler and teen, 0.0063 mg/(kg-d) for a child, and 0.0057 mg/(kg-d) for an adult. These values are based on studies in adults (Yang and Zhou 1994) and in infants (Shearer and Hadjimarkos 1975). The Health Canada values were selected for use in this assessment.

Silver

The critical effect in humans ingesting silver is a condition known as argyria. Argyria results from the deposition of silver in the dermis and also from silver-induced production of melanin and results in a permanent bluish-gray discoloration of the skin. Although the deposition of silver is permanent, it is not associated with any adverse health effects. Pathologic changes or inflammatory reactions have not been shown to result from silver deposition.

Health Canada (2009c) does not provide oral or inhalation TRVs for silver.

The U.S. EPA (2011, last updated 1996) provides an oral RfD of 0.005 mg/(kg-d) based on a 2 to 9 year study in humans. A LOAEL of 1 g (total dose) - converted to 0.014 mg/(kg-d) - was determined based on the development of argyria. An uncertainty factor of 3 was applied to the LOAEL to account for minimal effects in a subpopulation which has exhibited an increased propensity for the development of argyria. This value was used in this assessment.

Strontium

Once in the body, strontium behaves very much like calcium. A large portion of the strontium will accumulate in bone. In adults, strontium mostly attaches to the surfaces of bones. In juveniles, especially those with poor nutrition, strontium behaves as an imperfect surrogate for calcium and interferes with bone mineralization in the developing skeleton. Animal studies strongly support the identification of bone as the most sensitive target of strontium toxicity.

Health Canada (2009c) does not provide oral or inhalation exposure limits for strontium. The U.S. EPA IRIS database (2011, last updated 1996) provides a chronic RfD for oral exposure to strontium of 0.6 mg/(kg-d) based on rachitic bone in rats. This value was used in the assessment.

Thallium

Thallium is widely distributed in trace amounts in the earth's crust and can be found in pure form or mixed with other metals. Thallium is present in air, water, and soil, predominantly in the more stable thallous form. Exposure to thallium is generally low since levels in air, water and food tend to be low. The greatest exposure to thallium occurs as a result of ingestion of contaminated fruits and vegetables grown in areas near coal-burning power plants, cement factories, and smelting operations. Thallium is easily taken up by plants through their roots. The other main exposure route of thallium is smoking; people who smoke have twice as much thallium in their bodies as do non-smokers (ATSDR 2011, last updated 1992).

Very few agencies report exposure limits for thallium. The MOE (2009) provides an oral RfD of 1.35×10^{-5} mg/kg-d, based on the CalEPA's Public Health Goal for thallium in drinking water (CalEPA 1999). A NOEL of 0.0405 mg/(kg-d) for hair loss in rats was identified from a 90-day drinking water study. A cumulative uncertainty factor of 3,000 was applied: 10 for the use of a subchronic study; 10 for interspecies extrapolation; 10 for intraspecies variation; and 3 as a modifying factor for the steep dose-response curve.

The RfD of 1.35×10^{-5} mg/(kg-d) is extremely conservative; however, it was used in this assessment for lack of other data.

Uranium

Uranium is a natural and commonly occurring radioactive element, and can be found in varying amounts in rocks, soil, water, air, plants and animals. Natural uranium exists as a mixture of three isotopes, and the relative composition of each will determine how radioactive the uranium is. People are exposed to uranium from air, water, food, and soil. Food and water have small amounts of uranium, while root vegetables tend to have higher concentrations of uranium than other foods (ATSDR 2011, last updated 1999).

The U.S. EPA (2011, last updated 1989) derived an oral RfD of 0.003 mg/(kg-d) for soluble uranium salts. The point of departure was a LOAEL of 2.8 mg/(kg-d) for body weight loss and moderate nephrotoxicity in rabbits.

Health Canada (2009c) provides an oral RfD of 0.0006 mg/(kg-d) for exposure to uranium, derived from a LOAEL of 0.06 mg/(kg-d) for nephrotoxic and hepatotoxic effects in rats administered uranium in drinking water. This value is more conservative than the U.S. EPA value, and has been reviewed more recently. As such, the Health Canada value was used in the assessment.

Vanadium

Vanadium is a naturally occurring element and found naturally on the earth's crust as well as in fuel oils and coal. It is a white to gray metal, often found as a crystal. In the environment, vanadium is usually combined with other elements such as oxygen, sodium, sulfur or chloride.

Based on animal studies, the distribution of vanadium following oral exposure is rapid, and primarily distributed to the bones. Following intermediate duration dosing studies, the amount of vanadium reaching the tissues are low, with the highest levels in the kidney, bones, liver and lungs, initially. Prolonged retention of vanadium occurs only in the skeleton.

The U.S. EPA (2011, last updated in 1996) provides an oral RfD of 0.009 mg/(kg-d) for vanadium pentoxide, based on a NOAEL of 17.9 ppm (0.89 mg/(kg-d) equivalent) as determined by Stokinger *et al*. (1953, as cited in U.S. EPA 2011). An uncertainty factor of 100 was applied, 10 for interspecies extrapolation and a factor of 10 to provide added protection for unusually sensitive individuals.

The MOE (2009) provides an oral RfD of 2.1×10^{-3}, reported as a CalEPA Drinking Water Public Health Goal (2000). However, no value for vanadium is provided on the CalEPA's list of public health goals. As such, this value was not used in the assessment.

Health Canada (2009c) does not provide oral or inhalation TRVs for exposure to vanadium; however, the Health Canada Food Directorate provides a TRV for vanadium of 0.005 mg/(kg-d) (Health Canada 2002). The basis of this value has not been provided; nonetheless, this value was used in the assessment.

The WHO (2000) provides a guideline concentration for vanadium in air of 0.001 mg/m^3 for chronic respiratory tract effects in occupationally exposed workers. Although this value was derived as a 24-hour time weighted average, it is provided as a chronic TRV by the MOE (2009) and thus was used in the assessment to evaluate potential adverse effects resulting from chronic inhalation exposure to vanadium.

Zinc

Zinc is an essential nutrient with Recommended Daily Allowance (RDA) values ranging from 5 to 15 mg/day for different age and sex categories. The RDA is an estimate of the zinc needed for growth, development, metabolism, and tissue maintenance for over 98% of the healthy population.

Health Canada (2009c) provides age-dependent TRVs for zinc for the toddler, child, teen and adult of 0.478, 0.476, 0.536 and 0.566 mg/(kg-d), respectively, based on reduced iron and copper status in adults and increased growth in infants. These values were used in the assessment.

5.2.2 Carcinogenic TRVs

Carcinogenesis is generally assumed to be a "non-threshold" type phenomenon whereby it is assumed that any level of exposure to a carcinogen poses a finite probability of generating a carcinogenic response. Carcinogenic TRVs are generally referred to as slope factors (SF) or unit risks (UR) and are used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. The carcinogenic TRV is, therefore, the lifetime cancer risk per unit of dose. Of the COPC, arsenic, cadmium, chromium and nickel are considered carcinogenic. The carcinogenic TRVs associated with each of these COPC are discussed below.

Arsenic

Arsenic exposure *via* the oral route is considered to be carcinogenic based on the incidence of skin cancers in epidemiological studies examining human exposure through drinking water (Tseng *et al*. 1968; Tseng 1977). The slope factor (SF) used in this assessment represents an upper bound (95^{th} percentile) dose-response estimate. The SF is conservative and is meant to protect susceptible members of the public. The SF for arsenic of 1.8 $(mg/(kg\text{-}d))^{-1}$ was obtained from Health Canada (2009c) and is related to the development of internal cancers, such as stomach and liver.

Cadmium

The International Agency for Research on Cancer (IARC) classifies cadmium as carcinogenic to humans. None of the agencies report oral slope factors for exposure to cadmium, and the U.S. EPA states that there are no positive studies of orally ingested cadmium suitable for quantitation. The U.S. EPA (2011, last updated 1994) reports an inhalation unit risk (UR) of 1.8 $(mg/m^3)^{-1}$ for lung, trachea and bronchus cancer deaths in human male occupational workers exposed in the workplace, derived using a two-stage extrapolation model with extra risk. Health Canada (2009c) reports a much higher unit risk of 9.8 $(mg/m^3)^{-1}$ for increased incidence of lung tumours. This value was derived using a multistage model from a tolerable concentration of 0.0029 mg/m^3 in rats (0.0051 mg/m^3 after adjustment for exposure duration and human equivalency). The Health Canada value was reviewed more recently and was therefore used in this assessment. Additionally, the MOE (2009) supports the use of this value.

Chromium

The U.S. EPA (2011, last updated 1998) provides an inhalation UR of 12 $(mg/m^3)^{-1}$ for mortality resulting from lung cancer. The unit risk is based on occupational data that relate inhalation of chromium to lung cancer rates in exposed workers. The relationship between exposure to chromium and occurrence of lung cancer was considered sufficient to derive a dose-response relationship. A multistage, extra risk extrapolation method was employed to derive the unit risk.

Health Canada (2009c) provides an inhalation unit risk of 10.9 $(mg/m^3)^{-1}$ for total chromium, based on lung cancer incidence in humans exposed occupationally from 1 to 8 years. A tolerable concentration of 0.0046 mg/m^3 was used as the point of departure. This value is similar to the value from the U.S. EPA and was used in the assessment.

Nickel

The U.S. EPA (2011, last updated 1991) provides inhalation UR values of 0.24 $(mg/m^3)^{-1}$ and 0.48 $(mg/m^3)^{-1}$ for nickel refinery dust and nickel subsulphide, respectively. The values are based on lung cancer incidence from 4 separate human occupational inhalation exposure studies. The value of 0.24 $(mg/m^3)^{-1}$ is the midpoint of the ranges of risks from the studies, while the value of 0.48 $(mg/m^3)^{-1}$ is the value for nickel refinery dust but multiplied by 2 since refinery dust is approximately 50% nickel subsulphide.

Health Canada (2009c) provides inhalation UR values of 1.3 $(mg/m^3)^{-1}$ for soluble and insoluble forms of nickel and 0.71 $(mg/m^3)^{-1}$ for soluble nickel (primarily nickel chloride and nickel sulphate). The former was derived from a tolerable concentration range of 0.04 to 1 mg/m^3 for lung and nasal cancer, based on epidemiological studies at INCO mining, smelting and refinery operations in Ontario. The latter was derived from a tolerable concentration of 0.07 mg/m^3, based on human occupational exposure studies at nickel refineries in Norway.

In this assessment, the more conservative value of 1.3 $(mg/m^3)^{-1}$ from Health Canada was used as the inhalation UR.

Table 5.7 Summary of Human Toxicological Reference Values

COPC	Dermal RAF [a] (-)	Oral Toxicological Reference Value [b]: SF $(mg/(kg\text{-}d))^{-1}$		Oral Toxicological Reference Value [b]: RfD $(mg/(kg\text{-}d))$		Oral Toxicological Reference Value [b]: Endpoint	Inhalation Toxicological Reference Value: UR $(mg/m^3)^{-1}$		Inhalation Toxicological Reference Value: RfC (mg/m^3)		Inhalation Toxicological Reference Value: Endpoint
Antimony	0.1	N/A		4.0×10^{-4}	IRIS (last updated 1991)	Longevity, blood glucose and cholesterol	N/A		2.0×10^{-4}	U.S. EPA 2008	Pulmonary toxicity, chronic interstitial inflammation
Arsenic	0.03	1.8	HC 2009b	N/A		Internal cancers	6.4	HC 2009c	N/A		Lung cancer
Barium	0.1	N/A		1.6×10^{-2}	HC 2009c	Cardiovascular disease, increased blood pressure	N/A		N/A		N/A
Cadmium	0.01	N/A		1.0×10^{-3}	HC 2009c	Renal tubular dysfunction	9.8	HC 2009c	N/A		Lung cancer
Chromium	0.1	N/A		1.0×10^{-3}	HC 2009c	Damage to the gastrointestinal mucosa	10.9	HC 2009c	N/A		Lung cancer
Cobalt	0.1	N/A		1.0×10^{-3}	MOE 2009, modified from ATSDR (last updated 2004)	Haematological effects (polycythemia)	N/A		5.0×10^{-4}	RIVM 2001	Interstitial lung disease, asthma
Copper	0.06	N/A		0.091 (tod) 0.111 (child) 0.126 (teen) 0.141 (adult)	HC 2009c	Gastrointestinal effects	N/A		N/A		N/A
Lead	0.006	N/A		3.6×10^{-3}	HC 2009c	Increased concentration of lead in blood	N/A		N/A		N/A
Manganese	0.1	N/A		0.136 (tod) 0.122 (child) 0.142 (teen) 0.156 (adult)	HC 2009c	Neurotoxicity	N/A		N/A		N/A
Mercury	0.1	N/A		3×10^{-4}	HC 2009c	Nephrotoxicity	N/A		3×10^{-4}	IRIS (last updated 1995)	Nephrotoxicity
Molybdenum	0.01	N/A		0.023 (tod) 0.023 (child) 0.027 (teen) 0.028 (adult)	HC 2009c	Reproductive effects	N/A		N/A		N/A
Nickel	0.085	N/A		1.1×10^{-2}	HC 2009c	Perinatal lethality	1.3	HC 2009c	2.0×10^{-5}	HC 2009c	Lung lesions/ Lung, nasal cancers

Table 5.7 Summary of Human Toxicological Reference Values (Cont'd)

COPC	Dermal	Oral Toxicological Reference Value [b]				Inhalation Toxicological Reference Value			
	RAF [a]	SF	RfD		Endpoint	UR	RfC		Endpoint
	(-)	(mg/(kg-d))$^{-1}$	(mg/(kg-d))			(mg/m^3)$^{-1}$	(mg/m^3)		
Selenium	0.01	N/A	0.0062 (tod) 0.0063 (child) 0.0062 (teen) 0.0057 (adult)	HC 2009c	Selenosis	N/A	N/A		N/A
Silver	0.25	N/A	5.0×10^{-3}	IRIS (last updated 1996)	Argyria	N/A	N/A		N/A
Strontium	0.1	N/A	0.6	IRIS (last updated 1992)	Rachitic bone	N/A	N/A		N/A
Thallium	0.01	N/A	1.35×10^{-5}	MOE 2009; CalEPA 1999	Hair loss in male and female rats	N/A	N/A		N/A
Uranium	0.1	N/A	6.0×10^{-4}	HC 2009c	Nephrotoxicity, hepatotoxicity	N/A	N/A		N/A
Vanadium	0.1	N/A	5.0×10^{-3}	HC 2002	Developmental retardation	N/A	1.0×10^{-3}	WHO 2000	Chronic respiratory tract effects
Zinc	0.1	N/A	0.478 (tod) 0.476 (child) 0.536 (teen) 0.566 (adult)	HC 2009c	Increased growth (infant)	N/A	N/A		N/A

Notes:

a -	Dermal Relative Absorption Factors (RAF) from PQRA spreadsheet Health Canada (2009d).
b -	In the absence of toxicity benchmarks for dermal exposure, the oral toxicity benchmarks are used
N/A	Not applicable / no data available
RfD	Reference Dose for threshold acting chemical (i.e., non-carcinogenic effects).
RfC	Reference Concentration for threshold acting chemical (i.e., non-carcinogenic effects).
SF	Slope factor for carcinogenic effects
UR	Unit Risk for carcinogenic effects
ATSDR	Agency for Toxic Substances Disease Registry (ATSDR 2011, various updates)
IRIS	U.S. EPA Integrated Risk Information System (U.S. EPA 2011, various updates)
HC	Health Canada
CalEPA	California Environmental Protection Agency
MOE	Ontario Ministry of the Environment
RAIS	Risk Assessment Information System (University of Tennessee 2009)
RIVM	National Institute of Public Health and Environmental Protection

6.0 RISK ASSESSMENT

6.1 ECOLOGICAL RISK ASSESSMENT

A weight-of-evidence approach was used to determine potential ecological effects. A quantitative assessment was completed by comparing estimated intakes or media concentrations to the toxicological reference values (TRVs) to derive a screening index (SI), as shown in Equation 6-1.

$$SI = \frac{Concentration\ or\ Intake}{TRV} \qquad (6\text{-}1)$$

The SI values reported in this section are not estimates of the probability of ecological effect. Rather, the values are positively correlated with the potential of an effect, i.e., higher index values imply a greater potential of an effect. Different magnitudes of the SI value have been used in other studies to screen for potential ecological effects. An SI benchmark value of 1.0 has been used in some instances (e.g., Suter 1991). In this study, for the aquatic assessment an SI benchmark value of 1.0 is used, but for the terrestrial assessment SI benchmark values of less than 1 are used to reflect the home range of the species as presented in Table 3.2. An SI value above the benchmark does not necessarily indicate an effect but highlights combinations of receptors and COPC that require further consideration. In addition to the quantitative approach, field observations and spatial considerations were used in the overall assessment.

6.1.1 Aquatic Environment

As discussed previously (Section 4.2.1), aquatic receptors were evaluated in a total of 12 areas (Lightning Creek [LC], Christal Creek at the outlet of Christal Lake [CC at Outlet of CL], Christal Creek downstream of Christal Lake [CC d/s of CL], Upper and Lower South McQuesten River [Upper and Lower SMQR], Brefault and Flat Creeks upstream and downstream of the adits [BC & FC u/s and d/s of adits], Galena Creek upstream and downstream of the adit [GC u/s and d/s of adit], No Cash Creek [NCC], Sandy and Star Creeks [SaC & StC], and background [Bkgd]). These water bodies were evaluated for all aquatic receptors with the exception of fish in the smaller tributaries on Galena Hill (Brefault, Flat, Galena, No Cash, Sandy and Star Creeks). Benthic invertebrates in these water bodies were also not evaluated for exposure to sediment since recent (post 2000) sediment data were not available.

6.1.1.1 Water Quality

The potential effects of surface water on aquatic biota were assessed through a comparison of the reasonable maximum exposure concentrations to the aquatic TRVs (Table 5.2). The results of the assessment are summarized in Table 6.1. **Bold** and shaded values indicate that the water concentration exceeds the applicable TRV (i.e., SI value greater than 1).

From Table 6.1 it can be seen that the concentrations of antimony, arsenic, cobalt, mercury, molybdenum, selenium, strontium, uranium and vanadium are not a concern to aquatic receptors. Concentrations of cadmium, chromium, copper, iron, lead, manganese, nickel, silver and zinc exceed the aquatic TRVs for one or more aquatic receptors at one or more of the areas of the historic Keno Hill Mine site. This is not surprising since, as discussed previously (Section 2.2.1), several of these COPC have been found to be present in surface water at concentrations exceeding CCME guidelines that are protective of aquatic receptors.

The TRVs for aquatic plants are only exceeded for chromium in Lightning Creek, Brefault and Flat Creeks upstream and downstream of the adits, Galena Creek downstream of the adits, and Sandy and Star Creeks. Manganese concentrations result in an SI value of 1.3 for predator fish in Christal Creek at the outlet of Christal Lake, and SI values for zooplankton of 1.2 and 1.3 at Brefault and Flat Creeks upstream and downstream of the adits, respectively. The nickel concentration minimally exceeds the TRV for phytoplankton at Upper South McQuesten River, but nowhere else. Silver concentrations result in SI values above 1 for zooplankton and fish in the lower South McQuesten River, and for zooplankton in Lightning Creek, Christal Creek and Galena Creek upstream of the adits.

Concentrations of cadmium, copper, iron, lead and zinc result in SI values above 1 for a number of aquatic receptors at a number of locations. Both zinc and cadmium have been identified as key constituents of concern in more than one aquatic environment assessment (Laberge 2005; Minnow 2008, 2009). It should be noted that zinc concentrations also exceed the TRVs at the background locations, which is not unexpected given that this is a mineralized area and remaining resources in the area are estimated to be 2.2% zinc (Minnow 2008; Alexco 2007); however, concentrations of zinc are higher at other assessment locations. It should be noted that zinc levels in fish tissue are elevated in most of the mining affected waters. For example, sculpins from the Keno Hill area have zinc levels much greater than sculpins captured near the tailings discharge area at the Faro Mine site (WMEC 2006).

Exceedances of applicable TRVs for these COPC generally occur in Lightning Creek and Christal Creek. Extensive placer mining has and continues to occur in the Lightning Creek and Duncan Creek watersheds (Minnow 2010c), which may explain the elevated concentrations in Lightning Creek. Christal Lake receives seepage from mine structures and contains historical tailings deposits within it and nearby (i.e., the Mackeno Tailings), while Christal Creek receives seepage from mine structures on Keno and Galena Hills (Minnow 2009); these sources explain the elevated concentrations in Christal Creek. The zinc concentrations observed in the Upper South McQuesten River may not be entirely related to Keno Hill Mine activities since the water concentrations at KV-1 have been increasing since 2007 as a result of loads from Cache Creek from natural acid rock drainage in the Cache Creek watershed (EDI 2005).

Minnow (2009) has indicated that there are no clear differences in overall fish species diversity between mine-exposed and reference areas since average relative fish abundance at all mine-exposed creeks and areas downstream of the South McQuesten River were similar to or higher than at the reference area. There is lower diversity of fish in Christal Creek; however this may be due to physical habitat conditions, such as barriers, and not as a result of mining activities (Minnow 2009).

Exceedances also occur in the minor tributaries on Galena Hill. Most of these are not surprising since the water monitoring stations are located immediately downstream of point sources. The exceedances at Brefault, Flat and Galena Creeks upstream of their respective adits are somewhat surprising since they have been recommended to be used as reference locations (Minnow 2010b); however, the Keno Hill area is a very high grade district with numerous mineral deposits and thus the results are not completely unexpected. Despite the exceedances, it must be pointed out that these are very small water courses and do not provide comparable habitat to downstream monitoring locations. Additionally, No Cash, Sandy and Star Creeks are minor and do not discharge to any other watercourse (Minnow 2010b).

Table 6.1 Screening Index Values for Aquatic Receptors at the Historic Keno Hill Mine Site

COPC and Aquatic Receptor	Aquatic TRV (mg/L)	Screening Index Value											
		LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	BC/FC u/s of adits	BC/FC d/s of adits	GC u/s of adit	GC d/s of adit	NCC	SaC/ StC	Bkgd
Antimony													
Aquatic Plants	-	-	-	-	-	-	-	-	-	-	-	-	-
Phytoplankton	0.24	0.003	0.007	0.002	0.001	0.01	0.004	0.002	0.005	0.004	0.006	0.002	0.002
Benthic Invertebrates	2.6	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zooplankton	1.35	<0.001	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Predator Fish	4	<0.001	<0.001	<0.001	<0.001	<0.001	N/A	N/A	N/A	N/A	N/A	N/A	<0.001
Forage Fish	2.31	<0.001	<0.001	<0.001	<0.001	0.001	N/A	N/A	N/A	N/A	N/A	N/A	<0.001
Arsenic													
Aquatic Plants	0.25	0.06	0.06	0.02	0.008	0.04	0.02	0.03	0.03	0.01	0.02	0.02	0.07
Phytoplankton	0.02	0.79	0.73	0.24	0.10	0.44	0.29	0.31	0.33	0.15	0.29	0.21	0.87
Benthic Invertebrates	0.32	0.05	0.05	0.02	0.006	0.03	0.02	0.02	0.02	0.01	0.02	0.01	0.05
Zooplankton	0.91	0.02	0.02	0.005	0.002	0.01	0.006	0.007	0.007	0.003	0.006	0.005	0.02
Predator Fish	0.14	0.11	0.10	0.04	0.01	0.06	N/A	N/A	N/A	N/A	N/A	N/A	0.12
Forage Fish	0.12	0.13	0.12	0.04	0.02	0.07	N/A	N/A	N/A	N/A	N/A	N/A	0.15
Cadmium													
Aquatic Plants	3	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	0.006	0.006	<0.001
Phytoplankton	0.003	0.08	0.87	0.42	0.22	0.26	**3.4**	0.75	0.20	0.32	**6.0**	**6.4**	0.21
Benthic Invertebrates	0.12	0.002	0.02	0.01	0.006	0.007	0.09	0.02	0.005	0.008	0.15	0.16	0.005
Zooplankton	0.00075	0.30	**3.5**	**1.7**	0.88	**1.1**	**14**	**3.0**	0.79	**1.3**	**24**	**26**	0.85
Predator Fish	0.002	0.11	**1.3**	0.64	0.33	0.40	N/A	N/A	N/A	N/A	N/A	N/A	0.32
Forage Fish	0.009	0.03	0.29	0.14	0.07	0.09	N/A	N/A	N/A	N/A	N/A	N/A	0.07
Chromium													
Aquatic Plants	0.002	**1.7**	0.89	0.79	0.47	0.45	**1.1**	**1.6**	0.95	**1.2**	0.79	**1.9**	0.31
Phytoplankton	-	-	-	-	-	-	-	-	-	-	-	-	-
Benthic Invertebrates	-	-	-	-	-	-	-	-	-	-	-	-	-
Zooplankton	0.006	0.56	0.30	0.26	0.16	0.15	0.37	0.54	0.32	0.38	0.26	0.65	0.10
Predator Fish	0.073	0.05	0.02	0.02	0.01	0.01	N/A	N/A	N/A	N/A	N/A	N/A	0.008
Forage Fish	-	-	-	-	-	-	N/A	N/A	N/A	N/A	N/A	N/A	-

Table 6.1 Screening Index Values for Aquatic Receptors at the Historic Keno Hill Mine Site (Cont'd)

COPC and Aquatic Receptor	Aquatic TRV (mg/L)	Screening Index Value											
		LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	BC/FC u/s of adits	BC/FC d/s of adits	GC u/s of adit	GC d/s of adit	NCC	SaC/ StC	Bkgd
Cobalt													
Aquatic Plants	-	-	-	-	-	-	-	-	-	-	-	-	-
Phytoplankton	0.22	0.01	0.006	0.003	0.02	0.009	0.005	0.008	0.003	0.004	0.006	0.01	0.001
Benthic Invertebrates	1.6	0.001	<0.001	<0.001	0.003	0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.001
Zooplankton	0.005	0.47	0.28	0.12	0.90	0.38	0.24	0.33	0.12	0.16	0.26	0.46	0.05
Predator Fish	0.12	0.02	0.01	0.005	0.04	0.02	N/A	N/A	N/A	N/A	N/A	N/A	0.002
Forage Fish	0.2	0.01	0.007	0.003	0.02	0.01	N/A	N/A	N/A	N/A	N/A	N/A	0.001
Copper													
Aquatic Plants	0.12	0.09	0.04	0.03	0.05	0.04	0.04	0.08	0.05	0.04	0.05	0.05	0.02
Phytoplankton	0.004	**2.7**	**1.3**	0.95	**1.4**	**1.3**	**1.1**	**2.4**	**1.5**	**1.3**	**1.5**	**1.5**	0.48
Benthic Invertebrates	0.08	0.13	0.07	0.05	0.07	0.07	0.06	0.12	0.08	0.06	0.08	0.07	0.02
Zooplankton	0.0041	**2.6**	**1.3**	0.92	**1.4**	**1.3**	**1.1**	**2.3**	**1.5**	**1.2**	**1.5**	**1.4**	0.47
Predator Fish	0.0069	**1.6**	0.76	0.55	0.83	0.76	N/A	N/A	N/A	N/A	N/A	N/A	0.28
Forage Fish	0.0077	**1.4**	0.68	0.49	0.74	0.68	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Iron													
Aquatic Plants	-	-	-	-	-	-	-	-	-	-	-	-	-
Phytoplankton	-	-	-	-	-	-	-	-	-	-	-	-	-
Benthic Invertebrates	-	-	-	-	-	-	-	-	-	-	-	-	-
Zooplankton	1.48	**2.9**	**1.3**	0.68	0.41	0.94	**1.3**	**2.1**	0.82	**1.0**	0.72	**3.4**	0.35
Predator Fish	7.5	0.58	0.26	0.13	0.08	0.19	N/A	N/A	N/A	N/A	N/A	N/A	0.07
Forage Fish	0.6	**7.2**	**3.3**	**1.7**	**1.0**	**2.3**	N/A	N/A	N/A	N/A	N/A	N/A	0.85
Lead													
Aquatic Plants	145.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phytoplankton	0.63	0.07	0.04	0.01	0.002	0.15	0.01	0.02	0.05	0.005	0.05	0.007	<0.001
Benthic Invertebrates	0.019	**2.5**	**1.2**	0.48	0.08	**5.1**	0.26	0.52	**1.7**	0.17	**1.6**	0.25	0.03
Zooplankton	0.02	**2.3**	**1.1**	0.44	0.07	**4.7**	0.24	0.48	**1.6**	0.16	**1.5**	0.23	0.03
Predator Fish	0.022	**2.1**	1.0	0.40	0.07	**4.3**	N/A	N/A	N/A	N/A	N/A	N/A	0.02
Forage Fish	0.42	0.11	0.05	0.02	0.004	0.23	N/A	N/A	N/A	N/A	N/A	N/A	0.001

Table 6.1 Screening Index Values for Aquatic Receptors at the Historic Keno Hill Mine Site (Cont'd)

COPC and Aquatic Receptor	Aquatic TRV (mg/L)	Screening Index Value											
		LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	BC/FC u/s of adits	BC/FC d/s of adits	GC u/s of adit	GC d/s of adit	NCC	SaC/ StC	Bkgd
Manganese													
Aquatic Plants	12.4	0.006	0.08	0.02	0.02	0.04	0.18	0.20	0.006	0.009	0.12	0.11	0.005
Phytoplankton	37.1	0.002	0.03	0.007	0.005	0.01	0.06	0.07	0.002	0.003	0.04	0.04	0.002
Benthic Invertebrates	46	0.002	0.02	0.005	0.004	0.01	0.05	0.05	0.002	0.003	0.03	0.03	0.001
Zooplankton	1.8	0.05	0.53	0.14	0.11	0.25	**1.2**	**1.3**	0.04	0.06	0.79	0.78	0.03
Predator Fish	0.73	0.11	**1.3**	0.34	0.26	0.62	N/A	N/A	N/A	N/A	N/A	N/A	0.08
Forage Fish	2.06	0.04	0.47	0.12	0.09	0.22	N/A	N/A	N/A	N/A	N/A	N/A	0.03
Mercury													
Aquatic Plants	0.005	0.002	0.002	0.002	-	0.004	-	0.02	-	-	0.002	0.02	0.001
Phytoplankton	-	-	-	-	-	-	-	-	-	-	-	-	-
Benthic Invertebrates	-	-	-	-	-	-	-	-	-	-	-	-	-
Zooplankton	0.00087	0.01	0.01	0.01	-	0.02	-	0.12	-	-	0.01	0.12	0.006
Predator Fish	-	-	-	-	-	-	N/A	N/A	N/A	N/A	N/A	N/A	-
Forage Fish	0.00087	0.01	0.01	0.01	-	0.02	N/A	N/A	N/A	N/A	N/A	N/A	0.006
Molybdenum													
Aquatic Plants	-	-	-	-	-	-	-	-	-	-	-	-	-
Phytoplankton	5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Benthic Invertebrates	14.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zooplankton	0.45	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001
Predator Fish	0.2	0.003	0.003	0.003	0.004	0.003	N/A	N/A	N/A	N/A	N/A	N/A	0.003
Forage Fish	15	<0.001	<0.001	<0.001	<0.001	<0.001	N/A	N/A	N/A	N/A	N/A	N/A	<0.001
Nickel													
Aquatic Plants	0.18	0.03	0.04	0.02	0.17	0.06	0.03	0.03	0.02	0.02	0.05	0.06	0.01
Phytoplankton	0.03	0.17	0.21	0.11	**1.0**	0.36	0.17	0.15	0.10	0.14	0.33	0.34	0.07
Benthic Invertebrates	0.86	0.01	0.007	0.004	0.04	0.01	0.006	0.005	0.003	0.005	0.01	0.01	0.002
Zooplankton	0.06	0.08	0.11	0.06	0.50	0.18	0.09	0.07	0.05	0.07	0.16	0.17	0.03
Predator Fish	0.06	0.08	0.11	0.06	0.50	0.18	N/A	N/A	N/A	N/A	N/A	N/A	0.03
Forage Fish	0.29	0.02	0.02	0.01	0.10	0.04	N/A	N/A	N/A	N/A	N/A	N/A	0.01

Table 6.1 Screening Index Values for Aquatic Receptors at the Historic Keno Hill Mine Site (Cont'd)

COPC and Aquatic Receptor	Aquatic TRV (mg/L)	Screening Index Value											
		LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	BC/FC u/s of adits	BC/FC d/s of adits	GC u/s of adit	GC d/s of adit	NCC	SaC/ StC	Bkgd
Selenium													
Aquatic Plants	0.68	<0.001	0.002	0.001	<0.001	<0.001	0.001	0.001	0.002	<0.001	0.001	<0.001	<0.001
Phytoplankton	0.19	0.003	0.006	0.005	0.003	0.002	0.004	0.005	0.006	0.002	0.005	0.002	0.003
Benthic Invertebrates	0.18	0.004	0.006	0.005	0.003	0.003	0.004	0.005	0.006	0.002	0.005	0.002	0.003
Zooplankton	0.025	0.03	0.04	0.04	0.02	0.02	0.03	0.03	0.04	0.01	0.04	0.02	0.02
Predator Fish	0.1	0.01	0.02	0.02	0.01	0.01	N/A	N/A	N/A	N/A	N/A	N/A	0.01
Forage Fish	0.15	0.004	0.007	0.006	0.003	0.003	N/A	N/A	N/A	N/A	N/A	N/A	0.003
Silver													
Aquatic Plants	-	-	-	-	-	-	-	-	-	-	-	-	-
Phytoplankton	-	-	-	-	-	-	-	-	-	-	-	-	-
Benthic Invertebrates	-	-	-	-	-	-	-	-	-	-	-	-	-
Zooplankton	0.00058	**1.4**	**1.3**	0.20	0.14	**2.1**	0.29	0.62	**1.8**	0.16	0.90	0.10	0.08
Predator Fish	0.00092	0.86	0.80	0.13	0.09	**1.3**	N/A	N/A	N/A	N/A	N/A	N/A	0.05
Forage Fish	0.00104	0.76	0.71	0.11	0.08	**1.1**	N/A	N/A	N/A	N/A	N/A	N/A	0.04
Strontium													
Aquatic Plants	-	-	-	-	-	-	-	-	-	-	-	-	-
Phytoplankton	150	<0.001	0.002	0.002	0.002	0.001	0.002	0.003	0.001	0.002	0.002	<0.001	0.001
Benthic Invertebrates	10	0.009	0.03	0.02	0.02	0.02	0.03	0.05	0.02	0.03	0.04	0.01	0.02
Zooplankton	42	0.002	0.008	0.006	0.006	0.005	0.006	0.01	0.005	0.006	0.009	0.002	0.004
Predator Fish	9.3	0.009	0.04	0.03	0.03	0.02	N/A	N/A	N/A	N/A	N/A	N/A	0.02
Forage Fish	2.13	0.04	0.16	0.11	0.11	0.10	N/A	N/A	N/A	N/A	N/A	N/A	0.08
Uranium													
Aquatic Plants	2.96	<0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Phytoplankton	0.011	0.06	0.41	0.27	0.08	0.10	0.13	0.16	0.16	0.20	0.56	0.18	0.11
Benthic Invertebrates	0.82	<0.001	0.006	0.004	0.001	0.001	0.002	0.002	0.002	0.003	0.007	0.002	0.001
Zooplankton	0.011	0.06	0.41	0.27	0.08	0.10	0.13	0.16	0.16	0.20	0.56	0.18	0.11
Predator Fish	0.6	0.001	0.007	0.005	0.001	0.002	N/A	N/A	N/A	N/A	N/A	N/A	0.002
Forage Fish	0.16	0.004	0.03	0.02	0.005	0.007	N/A	N/A	N/A	N/A	N/A	N/A	0.008

Table 6.1 Screening Index Values for Aquatic Receptors at the Historic Keno Hill Mine Site (Cont'd)

COPC and Aquatic Receptor	Aquatic TRV (mg/L)	Screening Index Value												
		LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	BC/FC u/s of adits	BC/FC d/s of adits	GC u/s of adit	GC d/s of adit	NCC	SaC/ StC	Bkgd
Vanadium														
Aquatic Plants	-	-	-	-	-	-	-	-	-	-	-	-	-
Phytoplankton	0.90	0.005	0.003	0.001	0.001	<0.001	0.004	0.007	0.003	0.003	0.002	0.02	<0.001
Benthic Invertebrates	0.024	0.20	0.11	0.06	0.04	0.03	0.14	0.25	0.10	0.13	0.09	0.65	0.02
Zooplankton	1.9	0.003	0.001	<0.001	<0.001	<0.001	0.002	0.003	0.001	0.002	0.001	0.008	<0.001
Predator Fish	0.04	0.12	0.06	0.03	0.02	0.02	N/A	N/A	N/A	N/A	N/A	N/A	0.01
Forage Fish	0.04	0.12	0.06	0.03	0.02	0.02	N/A	N/A	N/A	N/A	N/A	N/A	0.01
Zinc														
Aquatic Plants	8.64	0.004	0.08	0.03	0.02	0.01	0.11	0.04	0.004	0.005	0.23	0.08	0.007
Phytoplankton	0.04	0.9	**16**	**7.2**	**3.2**	**2.2**	**23**	**7.5**	0.85	**1.1**	**51**	**18**	**1.5**
Benthic Invertebrates	0.28	0.13	**2.3**	**1.0**	0.45	0.31	**3.2**	**1.1**	0.12	0.16	**7.2**	**2.6**	0.22
Zooplankton	0.04	0.91	**16**	**7.2**	**3.2**	**2.2**	**23**	**7.5**	0.85	**1.1**	**51**	**18**	**1.5**
Predator Fish	0.06	0.61	**11**	**4.8**	**2.1**	**1.5**	N/A	N/A	N/A	N/A	N/A	N/A	**1.0**
Forage Fish	0.06	0.61	**11**	**4.9**	**2.1**	**1.5**	N/A	N/A	N/A	N/A	N/A	N/A	**1.0**

Notes: Values shaded in **bold** exceed indicate that the water concentration exceeds the applicable TRV (SI value > 1)

'-' No TRV available

N/A Not applicable; aquatic receptor not evaluated since water body is a minor tributary and are not fish bearing

LC	Lightning Creek	BC	Brefault Creek	SaC	Sandy Creek
CC	Christal Creek	FC	Flat Creek	StC	Star Creek
CL	Christal Lake	GC	Galena Creek	Bkgd	Background
SMQR	South McQuesten River	NCC	No Cash Creek		

6.1.1.2 Sediment Quality

The potential effects of the COPC on the benthic community were also assessed by comparing the reasonable maximum exposure concentrations to sediment benchmarks (Table 5.3). The assessment was conducted at fewer locations than the assessment of water since sediment data are not available for the minor tributaries on Galena Hill (Brefault, Flat, Galena, No Cash, Sandy and Star Creeks). It is unlikely that significant sediment deposits exist in these areas since these water courses are minor and are often near headwater.

It must be noted that the sediment quality data have been obtained from analyzing the fine fraction of sediments, while the sediment benchmarks are based on whole (bulk) sediment. Fine fractions tend to exhibit higher concentrations of metals since the smaller the size fraction, the larger the surface area to volume ratio, and the higher the amount of adsorbed metal to the particle. Additionally, the fine fraction may comprise only a small fraction of the total sediment sample, and analysis of the bulk sediment may show lower metal concentrations (i.e., the higher concentrations of metals associated with fine sediments would be diluted) (Minnow 2010a). The sediment quality may therefore not represent true concentrations to which benthic invertebrates and aquatic organisms would be exposed.

The results of the sediment assessment are presented in Table 6.2 for those COPC for which sediment benchmarks are available. As discussed previously in Section 5.1.1.2, the PEL values from the CCME and the SEL values from Thompson *et al.* (2005) were used in this assessment to identify whether adverse biological effects on sediment dwelling populations are likely to occur. For informational purposes, the CCME ISQG and LEL values from Thompson *et al.* (2005) are also provided in Table 6.2. From this table, it can be seen that the sediment concentrations exceed or more of the sediment benchmarks (i.e., SI value greater than 1) for most of the COPC at one or more location including background. These results are not unexpected since previous assessments have found several metals (arsenic, cadmium, copper, manganese, nickel, zinc) in sediment in the area at concentrations exceeding the probable effect levels (PELs) (Laberge 2005; Minnow 2009, 2010a). Chromium, molybdenum and vanadium are the only COPC for which none of the concentrations exceed sediment benchmarks.

Arsenic, cadmium, lead and zinc exceed these benchmarks, with the highest SI values occurring in Christal Creek near the outlet of Christal Lake. Historically, there is evidence of relatively low abundance and diversity of benthic organisms in Flat and Christal Creeks as compared to other reference and exposed areas, though to be correlated with higher concentrations of metals in water and sediment in these areas (Laberge 2008; Minnow 2009). These findings support the risk assessment results.

Although SI values for cadmium, lead and zinc are above 1.0 in South McQuesten River and Lightning Creek, the benthic invertebrate communities have been found to be healthy in these areas with a good representation of highly sensitive insects (Laberge 2008). Thus adverse effects on benthic communities are not expected in South McQuesten River and Lightning Creek.

Table 6.2 Screening Index Values for Sediment Exposure at the Historic Keno Hill Mine Site

COPC, Source and Type of Sediment Toxicity Benchmark		Sediment Benchmark (mg/kg)	Screening Index Value					
			LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	Bkgd
Arsenic								
CCME 2011	ISQG	5.9	**59**	**297**	**24**	**33**	**43**	**33**
	PEL	17	**21**	**103**	**8.5**	**11**	**15**	**11**
Thompson *et al*. 2005	LEL	9.8	**36**	**179**	**15**	**20**	**26**	**20**
	SEL	346.4	**1.0**	**5.1**	0.42	0.56	0.74	0.55
Cadmium								
CCME 2011	ISQG	0.6	**34**	**295**	**57**	**21**	**69**	**6.5**
	PEL	3.5	**5.8**	**51**	**10**	**3.7**	**12**	**1.1**
Thompson *et al*. 2005	LEL	-	-	-	-	-	-	-
	SEL	-	-	-	-	-	-	-
Chromium								
CCME 2011	ISQG	37.3	0.70	0.50	0.42	0.41	0.40	0.64
	PEL	90	0.29	0.21	0.17	0.17	0.17	0.26
Thompson *et al*. 2005	LEL	47.6	0.55	0.39	0.33	0.32	0.31	0.50
	SEL	115.4	0.23	0.16	0.14	0.13	0.13	0.21
Copper								
CCME 2011	ISQG	35.7	**1.1**	**2.5**	**1.2**	**1.0**	**4.1**	**1.3**
	PEL	197	0.20	0.45	0.21	0.18	0.74	0.24
Thompson *et al*. 2005	LEL	22.2	**1.8**	**4.0**	**1.9**	**1.6**	**6.5**	**2.1**
	SEL	268.8	0.15	0.33	0.15	0.13	0.54	0.18
Lead								
CCME 2002	ISQG	35	**12**	**127**	**20**	**20**	**84**	**1.3**
	PEL	91.3	**4.5**	**49**	**7.5**	**7.8**	**32**	0.49
Thompson *et al*. 2005	LEL	36.7	**11**	**121**	**19**	**19**	**80**	**1.2**
	SEL	412.4	0.99	**11**	**1.7**	**1.7**	**7.1**	0.11
Mercury								
CCME 2011	ISQG	0.17	**1.4**	0.67	0.70	0.75	**2.7**	0.57
	PEL	0.486	0.50	0.24	0.25	0.26	0.96	0.20
Thompson *et al*. 2005	LEL	-	-	-	-	-	-	-
	SEL	-	-	-	-	-	-	-
Molybdenum								
CCME 2011	ISQG	-	-	-	-	-	-	-
	PEL	-	-	-	-	-	-	-
Thompson *et al*. 2005	LEL	13.8	0.24	0.18	0.13	0.09	0.11	0.12
	SEL	1238.5	0.003	0.002	0.001	0.001	0.001	0.001
Nickel								
CCME 2011	ISQG	-	-	-	-	-	-	-
	PEL	-	-	-	-	-	-	-
Thompson *et al*. 2005	LEL	23.4	**1.3**	**4.6**	**1.5**	**3.4**	**2.5**	**1.5**
	SEL	484	0.06	0.22	0.07	0.17	0.12	0.07

Table 6.2 SI Values for Sediment Exposure at the Historic Keno Hill Mine Site (Cont'd)

COPC, Source and Type of Sediment Toxicity Benchmark		Sediment Benchmark (mg/kg)	Screening Index Value					
			LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	Bkgd
Selenium								
CCME 2011	ISQG	-	-	-	-	-	-	-
	PEL	-	-	-	-	-	-	-
Thompson *et al.* 2005	LEL	1.9	**1.3**	**1.6**	**1.2**	0.99	**2.5**	0.95
	SEL	16.1	0.16	0.19	0.15	0.12	0.30	0.11
Uranium								
CCME 2011	ISQG	-	-	-	-	-	-	-
	PEL	-	-	-	-	-	-	-
Thompson *et al.* 2005	LEL	104.4	0.01	0.07	**2.3**	0.02	0.01	0.01
	SEL	5874.1	<0.001	0.001	0.04	<0.001	<0.001	<0.001
Vanadium								
CCME 2011	ISQG	-	-	-	-	-	-	-
	PEL	-	-	-	-	-	-	-
Thompson *et al.* 2005	LEL	35.2	0.71	0.91	0.72	0.63	0.70	0.96
	SEL	160	0.16	0.20	0.16	0.14	0.15	0.21
Zinc								
CCME 2011	ISQG	123	**8.8**	**124**	**21**	**8.0**	**15**	**1.1**
	PEL	315	**3.4**	**48**	**8.1**	**3.1**	**5.9**	0.41
Thompson *et al.* 2005	LEL	-	-	-	-	-	-	-
	SEL	-	-	-	-	-	-	-

Notes: Values shaded in **bold** exceed indicate that the water concentration exceeds the applicable TRV (SI value > 1)
'-' No benchmark available
ISQG Interim Sediment Quality Guideline
PEL Probable Effect Level; LEL Lowest Effect Level; SEL Severe Effect Level
LC Lightning Creek; SMQR South McQuesten River; Bkgd Background
CC Christal Creek; CL Christal Lake

6.1.2 Terrestrial Environment

This section presents the results of the risk characterization for terrestrial receptors (birds and mammals) assessed at the different areas of the historic Keno Hill Mine site. The SI benchmark values used in the assessment for each species are based on their home range and are presented in each of the tables discussed below.

6.1.2.1 Evaluation of Potential Effects on Birds

Table 6.3 summarizes the SI values calculated from the estimated intakes (Table 4.22) and TRVs (Table 5.6) for the avian receptors assessed at the site. SI values shaded and in **bold** in Table 6.3 exceed the applicable benchmark SI value. Appendix D provides a sample calculation while Appendix B provides a breakdown of the pathways.

The SI values were calculated assuming that, while on site, the birds obtain all of their food from the location of interest. Because the mallard, merganser and scaup are migratory birds, it is estimated that they will be present on site 50% of the time. Thus, for these birds, an SI benchmark of 0.5 was used for comparison. The grouse, on the other hand, is assumed to be on site year round and thus an SI benchmark of 1 was used.

The assessment did not include an analysis of background exposure since the terrestrial vegetation and soil data from undisturbed ‘control’ areas were already included in the analysis of the Galena Hill and South McQuesten areas. The mallard, merganser and scaup were only evaluated at the Mackeno Tailings area since this area contains the largest water body (i.e., Christal Lake). The grouse was evaluated at five different locations since the home range of the grouse is relatively small (in essence 5 different grouse were considered). The potential adverse effects from avian exposure to antimony, silver, strontium, thallium and zirconium were not assessed due to a lack of available avian TRVs.

From Table 6.3, it can be seen that the SI values are above the benchmark of 0.5 for the scaup for exposure to arsenic, lead and zinc. The SI value for scaup for zinc is only slightly above the benchmark value of 0.5. The intakes of arsenic, lead and zinc are predominantly as a result of sediment ingestion (i.e., greater than 75%). The findings related to scaup present in the MT area are not surprising given that the sediment concentrations for the COPC in Christal Creek in this vicinity exceeded the sediment toxicity benchmarks (Section 6.1.1.2 and Table 6.2). None of the SI benchmark values are exceeded for other waterfowl in the area (mallard, merganser).

For grouse, the SI value is above 1 for exposure to lead in the Valley Tailings (VT) area which is primarily related to soil ingestion (89%). The terrestrial effects assessment studies conducted by EDI (2008, 2009, 2010) have revealed aerial contamination around the eastern ‘dry’ portion of the tailings facilities (i.e., VT), and concerns have been expressed regarding the potential for ongoing contamination from dry tailings dust to the adjacent ecosystem. The SI value of 1.5 for the grouse for exposure to lead in soil in this area supports this conclusion. It should be noted, however, that receptors are assumed to be present at the location of the reasonable maximum exposure concentration (2274 mg/kg) of lead for the entire time on site which is a conservative assumption. In reality, the grouse would move around in the area of the Valley Tailings and be exposed to an average concentration (478 mg/kg), which would result in an SI value of 0.4.

Table 6.3 Screening Index Values for Avian Receptors at the Historic Keno Hill Mine Site

Avian Receptor and Benchmark SI Value	Screening Index Value							
	Mallard	**Merganser**	**Scaup**	**Grouse**				
	0.5	**0.5**	**0.5**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
COPC	**MT**	**MT**	**MT**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Antimony	-	-	-	-	-	-	-	-
Arsenic	0.28	0.10	**0.74**	0.01	0.04	0.18	0.02	0.05
Barium	0.06	0.01	0.09	0.35	0.27	0.12	0.10	0.11
Cadmium	0.05	0.04	0.15	0.04	0.72	0.24	0.05	0.05
Chromium	<0.01	0.02	0.01	0.0	0.0	0.03	0.02	0.02
Cobalt	<0.01	<0.01	0.02	<0.01	0.05	0.01	<0.01	0.02
Copper	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01	<0.01
Lead	0.41	0.33	**1.4**	0.03	0.13	**1.5**	0.06	0.19
Manganese	0.04	0.04	0.2	0.03	0.05	0.10	0.03	0.05
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01
Selenium	0.06	0.16	0.10	0.01	0.38	0.03	0.01	0.02
Silver	-	-	-	-	-	-	-	-
Strontium	-	-	-	-	-	-	-	-
Thallium	-	-	-	-	-	-	-	-
Uranium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.02	<0.01	0.03	0.02	0.02	0.02	0.02	0.02
Zinc	0.22	0.14	**0.53**	0.04	0.45	0.39	0.10	0.13
Zirconium	-	-	-	-	-	-	-	-

Notes: Values shaded in **bold** exceed the benchmark SI value

GH Galena Hill

MT Mackeno Tailings

VT Valley Tailings

SK Silver King

SMQ South McQuesten

6.1.2.2 Evaluation of Potential Effects on Mammals

Table 6.4 summarizes the SI values calculated from the estimated intakes (Table 4.22) and TRVs (Table 5.6) for the mammalian ecological receptors assessed at the site. Screening Index values shaded and in **bold** in Table 6.4 exceed the applicable benchmark SI value. Appendix D provides a sample calculation. Appendix B provides a breakdown of the pathways.

The SI values were calculated assuming that, while on site, the receptors obtain all of their food from the location of interest. The beaver, bear, fox, hare, marmot, mink and sheep are assumed to spend 100% of their time on site, thus an SI benchmark value of 1.0 was used. The caribou and wolf are assumed to spend 50% and 25% of their time on site, respectively, and thus SI benchmark values of 0.5 and 0.25 were used to evaluate potential risks.

As indicated in the evaluation of birds, the assessment for mammals did not include an analysis of background exposure since the terrestrial vegetation and soil data from undisturbed ‘control’ areas were already included in the analysis of the Galena Hill and South McQuesten areas.

The bear, caribou, moose and wolf have very large home ranges and thus were evaluated site-wide (i.e., one receptor present across the entire Keno Hill Mine site), while all other species with small home ranges were evaluated at different locations. The beaver and mink were not evaluated at the Valley Tailings area since water courses around this area are primarily minor tributaries and are therefore not likely to provide adequate habitat for beaver or mink populations.

From Table 6.4, it can be seen that there are no predicted effects for the bear, caribou, fox, moose or wolf (i.e., SI values below the benchmark). Arsenic, cadmium, selenium and thallium exposures in some locations and for some receptors exceed the benchmark SI value of 1.0. Exposures to all other COPC are not expected to result in predicted effects for any of the receptors.

The SI values are above 1 for some species for exposure to arsenic at the Mackeno Tailings (beaver and mink), Valley Tailings (hare), Galena Hill (mink) and South McQuesten River (mink), and for the beaver and hare for exposure to cadmium at the Mackeno Tailings. For the beaver and mink, the intakes of arsenic are largely from ingestion of sediment. The maximum sediment concentration of arsenic (1750 mg/kg) was used in the assessment; however it should be highlighted that the arsenic sediment concentrations range from 32 mg/kg to 1750 mg/kg. For the mink, the exposure to cadmium at this area is also as a result of sediment ingestion. Again, the maximum concentration of cadmium (177 mg/kg) was used while the concentrations range from 2.5 mg/kg to 177 mg/kg. For the beaver at the Mackeno Tailings, the dominant exposure pathway for cadmium is browse ingestion. Only four measurements of cadmium in browse were available from the Mackeno Tailings area, and therefore the exposure point concentration was the maximum measured value (16.6 mg/kg). The cadmium concentrations in vegetation ranged from 0.31 to 16.6 mg/kg. Soil is the dominant exposure pathway for arsenic for the hare at the Valley Tailings area, while at the Mackeno Tailings area the dominant exposure pathway for the cadmium exposure is browse ingestion (i.e., 60%).

For the mink, exposure to selenium in the Galena Hill area also results in an SI value above 1 as a result of fish ingestion from water bodies in this area. The exposure point concentration of selenium in fish from this area is 2.58 mg/kg, with values ranging from 0.56 mg/kg to 2.98 mg/kg. Previous aquatic assessment studies have found higher metal concentrations in general in fish from the Galena Hill area (i.e., Lightning Creek) (WMEC 2006). Although this may be attributed to elevated water concentrations as a result of seepage and placer mining for some metals, the measured concentrations of selenium in water in this area are low, with a maximum value of 1.18 µg/L measured in April of 2009. Therefore, additional fish sampling and analysis of metals is needed to provide a better estimate of exposure.

The SI value for thallium is exceeded only at the Silver King area for the marmot and sheep, and is a result of forage ingestion (>99%). The exposure point concentration for thallium (0.74 mg/kg) in forage is high as a result of one measurement in 2010 of 2.62 mg/kg (EDI, unpublished data); other measurements from this area are much lower, ranging from below the MDL to 0.5 mg/kg. If the high thallium concentration is not included in the data set, then the exposure point concentration becomes 0.15 mg/kg and the SI values for the marmot and sheep decrease to 0.3 and 0.21, respectively. Thus, it is unlikely that sheep and marmot would experience any adverse effects as a result of exposure to thallium in the Silver King area.

6.1.2.3 Summary of Terrestrial Assessment

The results presented in the above section for the terrestrial receptors indicate that for the most part the concentrations of COPC in the terrestrial environment are unlikely to result in adverse effects on ecological receptors with a terrestrial-based diet. Possible exceptions include exposure to the hare where soil and browse concentrations of arsenic and cadmium are of potential concern, and exposure to grouse where soil concentrations of lead are of potential concern.

The results of the assessment indicate that concentrations of arsenic, cadmium and lead in sediment are of concern to ecological receptors with aquatic-based diets (beaver, mink and scaup). Selenium in fish in Lightning Creek may also pose a risk to mink in the area.

Table 6.4 Screening Index Values for Mammalian Receptors at the Historic Keno Hill Mine Site

Ecological Receptor and Benchmark SI Value	Screening Index Value															
	Bear	Beaver				Caribou	Fox					Hare				
	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
COPC	**UKHM**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Antimony	0.0	0.05	0.27	0.05	0.32	0.04	<0.01	<0.01	0.0	<0.01	0.02	<0.01	0.1	0.18	0.01	0.06
Arsenic	0.22	0.69	**3.0**	0.04	0.51	0.21	0.36	0.39	0.58	0.37	0.42	0.06	0.37	**1.2**	0.09	0.32
Barium	0.07	0.35	0.33	0.16	0.26	0.02	0.02	0.02	0.02	0.02	<0.01	0.52	0.45	0.23	0.25	0.30
Cadmium	0.04	0.13	**1.9**	0.12	0.19	0.03	0.06	0.11	0.10	0.06	0.07	0.12	**2.4**	0.8	0.15	0.14
Chromium	0.01	0.02	0.01	<0.01	0.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.03	0.0	0.0	0.0
Cobalt	<0.01	0.02	0.04	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	0.01
Copper	<0.01	0.05	0.05	0.04	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.04	0.04	0.04	0.02
Lead	0.02	0.06	0.15	0.02	0.24	0.04	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.02	0.15	<0.01	0.02
Manganese	0.05	0.05	0.44	0.02	0.14	0.03	<0.01	<0.01	0.03	<0.01	<0.01	0.09	0.26	0.25	0.11	0.15
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	<0.01	0.02	0.03	0.03	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	0.01	<0.01
Nickel	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01
Selenium	0.07	0.03	0.49	0.01	0.05	<0.01	0.24	0.54	0.25	0.24	0.25	0.03	0.80	0.07	0.03	0.05
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	<0.01	0.01	0.03	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Thallium	0.08	<0.01	0.01	0.02	0.02	0.01	0.22	0.22	0.23	0.32	0.22	0.02	0.06	0.10	0.84	0.03
Uranium	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.02	0.27	0.22	0.17	0.08	<0.01	0.02	0.02	0.02	0.02	0.02	0.05	0.06	0.08	0.07	0.05
Zinc	0.08	0.08	0.88	0.07	0.12	0.03	0.04	0.29	0.26	0.08	0.10	0.04	0.44	0.37	0.10	0.13
Zirconium	0.02	0.02	0.03	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.09	0.08	0.06	0.07

Notes: Values shaded in **bold** exceed the benchmark SI value

GH	Galena Hill	VT	Valley Tailings	SMQ	South McQuesten
MT	Mackeno Tailings	SK	Silver King	UKHM	Entirety of Keno Hill area

Table 6.4 Screening Index Values for Mammalian Receptors at the Historic Keno Hill Mine Site (Cont'd)

Ecological Receptor and Benchmark SI Value	Screening Index Value															
	Marmot					Mink				Moose	Sheep					Wolf
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.25
COPC	GH	MT	VT	SK	SMQ	GH	MT	SK	SMQ	UKHM	GH	MT	VT	SK	SMQ	UKHM
Antimony	<0.01	0.0	0.10	<0.01	0.03	0.03	0.20	0.02	0.21	0.01	<0.01	0.0	0.1	<0.01	0.03	<0.01
Arsenic	0.03	0.21	0.57	0.04	0.15	**1.3**	**4.0**	0.38	**1.1**	0.06	0.03	0.13	0.47	0.04	0.13	0.09
Barium	0.14	0.23	0.23	0.31	0.34	0.07	0.08	0.04	0.09	0.03	0.10	0.16	0.16	0.20	0.21	<0.01
Cadmium	<0.01	0.14	0.11	<0.01	0.03	0.13	0.63	0.1	0.22	0.10	<0.01	0.08	0.09	<0.01	0.03	0.02
Chromium	<0.01	0.0	0.0	0.0	0.0	0.36	0.04	<0.01	0.07	<0.01	<0.01	0.0	0.0	0.0	0.0	<0.01
Cobalt	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	<0.01	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.04	<0.01	<0.01	0.02	0.02	0.02	0.01	<0.01
Lead	<0.01	0.01	0.09	<0.01	<0.01	0.02	0.14	<0.01	0.12	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01
Manganese	0.07	0.31	0.16	0.11	0.10	0.02	0.40	<0.01	0.12	0.02	0.04	0.19	0.12	0.07	0.07	<0.01
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium	0.02	0.05	0.03	0.02	0.03	**1.3**	0.93	0.46	0.62	0.01	0.02	0.03	0.02	0.01	0.02	0.08
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thallium	0.03	0.10	0.12	**1.7**	0.04	0.23	0.23	0.40	0.26	<0.01	0.02	0.06	0.07	**1.1**	0.02	0.02
Uranium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.03	0.03	0.04	0.04	0.03	0.10	0.09	0.05	0.05	0.01	0.02	0.02	0.03	0.03	0.02	<0.01
Zinc	<0.01	0.05	0.09	0.03	0.05	0.12	0.74	0.07	0.22	0.08	<0.01	0.03	0.07	0.02	0.03	0.18
Zirconium	0.05	0.08	0.07	0.05	0.06	<0.01	<0.01	<0.01	<0.01	0.01	0.03	0.05	0.04	0.03	0.04	<0.01

Notes: Values shaded in **bold** exceed the benchmark SI value
GH Galena Hill VT Valley Tailings SMQ South McQuesten
MT Mackeno Tailings SK Silver King UKHM Entirety of Keno Hill area

6.2 HUMAN HEALTH

Risk characterization involves the integration of the information from the exposure assessment and the toxicity assessment. For the historic Keno Hill Mine site, both non-carcinogens and carcinogens were selected as COPC.

As indicated previously, human receptors were considered to be present in Galena Hill and South McQuesten areas.

6.2.1 Non-Carcinogenic Effects

For many non-carcinogenic effects, protective biological mechanisms must be overcome before an adverse effect is manifested from exposure to the COPC. This is known as a "threshold" concept. For non-carcinogenic COPC, the hazard quotient (HQ) was evaluated as follows:

$$HQ_{o/d} = \frac{I_{soil} + I_{water} + I_{food}}{TRV_o} + \frac{I^{s}_{dermal}}{TRV_d} \quad (6\text{-}2)$$

$$HQ_i = \frac{C_{air} \times F_{site}}{TRV_i}$$

Where:

$HQ_{o/d}$ = Hazard quotient – oral and dermal exposure [-]
HQ_i = Hazard quotient – inhalation exposure [-]
C_{air} = Concentration of COPC in air [mg/m^3]
F_{site} = Fraction of time at site [-]
I_{soil} = Intake of COPC through the ingestion of soil pathway [mg/(kg-d)]
I_{water} = Intake of COPC through the ingestion of water pathway [mg/(kg-d)]
I_{food} = Intake of COPC through the ingestion of food pathway [mg/(kg-d)]
I^{s}_{dermal} = Intake of COPC in soil through the dermal pathways [mg/(kg-d)]
TRV_i = Toxicological Reference Value for inhalation exposure [mg/m^3]
TRV_o = Toxicological Reference Value for oral exposure [mg/(kg-d)]
TRV_d = Toxicological Reference Value for dermal exposure [mg/(k-d)] (assumed equal to TRV_o)

As the TRVs for the oral (soil, water and food) and dermal (soil) pathways are based on the same information, the HQ values for these exposure routes are summed. Effects resulting from inhalation exposure are generally for a different endpoint compared to the oral route and are thus are summed only if the endpoint for the different routes of exposure is the same. In DQRAs, 20% of the dose, or a hazard quotient of 0.2, is generally used to assess acceptable exposure from each individual pathway. In this assessment inhalation of soil particulates, soil ingestion and dermal exposure, water intake and traditional food consumption over the year were evaluated; therefore, an HQ benchmark of 0.5 was considered appropriate for use at the historic Keno Hill Mine site.

The doses or intakes for the different pathways of exposure were presented in Section 4.4.2 for the toddler (results for all age groups are presented in Appendix B) and the TRVs used in this assessment were discussed in Section 5.2.

The HQ values for exposure to non-carcinogenic COPC are presented in Table 6.5 for the South McQuesten area and Table 6.6 for the Galena Hill area. As can be seen from these tables, inhalation exposure does not result in HQ values above the benchmark value of 0.5 for any of the COPC for any of the human receptors, while oral and dermal exposure to thallium and zinc result in HQ values above the benchmark for almost all age groups at both areas. The primary pathway of exposure is consumption of moose. The moose concentrations were estimated using literature feed-to-flesh transfer factors, and there is therefore some uncertainty associated with these values. For example, the predicted concentration of zinc in moose flesh is 688 mg/kg ww, and measured concentrations of zinc in the kidney and liver from two moose from the Keno Hill area are 25.2 mg/kg ww and 24.9 mg/kg ww, respectively. Zinc concentrations in kidney and liver from moose captured at the Faro Mine are similar (28.8 mg/kg ww and 23.9 mg/kg ww, respectively) and the measured zinc concentration in flesh was 79.67 mg/kg ww. These data suggest that the predicted concentrations in this assessment may be overestimated by at least a factor of eight. If the measured zinc concentrations in flesh from the Faro Mine are used in lieu of the estimated values, the HQ values are much lower. The results of the human health assessment suggest that moose flesh data need to be collected to verify the results of the risk assessment.

The exposure to thallium is as a result of background since thallium is not discharged in drainage water or released from tailings at the historic Keno Hill Mine site. As can be seen from the summary of environmental media data presented in Section 1.1, thallium concentrations are low and are often below the method detection limits. Thus, the HQ values reflect background and are elevated because of the TRV used in the assessment for oral exposure. The RfD of $1.35x10^{-5}$ mg/(kg-d) was derived by the CalEPA and was developed using a safety factor of 3000. The U.S. EPA (2011) does not currently provide an oral RfD for exposure to thallium; however, a value of $8x10^{-5}$ mg/(kg-d) has been reported previously. If this is used in lieu of the more conservative CalEPA value, then exposure from thallium is no longer a concern (i.e., the HQ values all decrease to below a value of 0.5). Therefore, exposure to thallium in the area is not expected to be a concern for human receptors.

Table 6.5 Hazard Quotients Calculated for Human Receptors at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Hazard Quotient - Toddler			Hazard Quotient - Child			Hazard Quotient - Teen			Hazard Quotient - Adult		
	Oral + Dermal	Inhalation	Total	Oral + Dermal	Inhalation	Total	Oral + Dermal	Inhalation	Total	Oral + Dermal	Inhalation	Total
Antimony	0.29	8.7×10^{-6}	NA	0.21	8.7×10^{-6}	NA	0.15	8.7×10^{-6}	NA	0.13	8.7×10^{-6}	NA
Barium	5.2×10^{-2}	-	5.2×10^{-2}	3.6×10^{-2}	-	3.6×10^{-2}	3.5×10^{-2}	-	3.5×10^{-2}	3.4×10^{-2}	-	3.4×10^{-2}
Cadmium	0.20	-	0.20	0.15	-	0.15	0.11	-	0.11	0.09	-	0.09
Chromium	0.18	-	0.18	0.11	-	0.13	0.10	-	0.10	0.08	-	0.08
Cobalt	7.1×10^{-2}	5.7×10^{-6}	NA	5.2×10^{-2}	5.7×10^{-6}	NA	3.6×10^{-2}	5.7×10^{-6}	NA	3.3×10^{-2}	5.7×10^{-6}	NA
Copper	2.6×10^{-2}	-	2.6×10^{-2}	1.5×10^{-2}	-	1.5×10^{-2}	9.9×10^{-3}	-	9.9×10^{-3}	7.5×10^{-3}	-	7.5×10^{-3}
Lead	0.44	-	0.44	0.31	-	0.31	0.22	-	0.22	0.21	-	0.21
Manganese	0.11	-	0.11	8.8×10^{-2}	-	8.8×10^{-2}	5.8×10^{-2}	-	5.8×10^{-2}	4.7×10^{-2}	-	4.7×10^{-2}
Mercury	0.16	1.7×10^{-8}	0.16	0.12	1.7×10^{-8}	0.12	8.6×10^{-2}	1.7×10^{-8}	8.6×10^{-2}	7.2×10^{-2}	1.7×10^{-8}	7.2×10^{-2}
Molybdenum	5.6×10^{-3}	-	5.6×10^{-3}	4.4×10^{-3}	-	4.4×10^{-3}	2.6×10^{-3}	-	2.6×10^{-3}	2.1×10^{-3}	-	2.1×10^{-3}
Nickel	0.11	5.3×10^{-4}	NA	0.08	5.3×10^{-4}	NA	5.7×10^{-2}	5.3×10^{-4}	NA	4.9×10^{-2}	5.3×10^{-4}	NA
Selenium	0.16	-	0.16	0.12	-	0.12	8.7×10^{-2}	-	8.7×10^{-2}	8.0×10^{-2}	-	8.0×10^{-2}
Silver	1.3×10^{-2}	-	1.3×10^{-2}	9.2×10^{-3}	-	9.2×10^{-3}	6.7×10^{-3}	-	6.7×10^{-3}	5.9×10^{-3}	-	5.9×10^{-3}
Strontium	6.5×10^{-3}	-	6.5×10^{-3}	4.7×10^{-3}	-	4.7×10^{-3}	3.4×10^{-3}	-	3.4×10^{-3}	3.2×10^{-3}	-	3.2×10^{-3}
Thallium	**2.3**	-	**2.3**	**1.7**	-	**1.7**	**1.2**	-	**1.2**	**1.0**	-	**1.0**
Uranium	2.7×10^{-2}	-	2.7×10^{-2}	1.9×10^{-2}	-	1.9×10^{-2}	1.4×10^{-2}	-	1.4×10^{-2}	1.3×10^{-2}	-	1.3×10^{-2}
Vanadium	3.7×10^{-2}	2.2×10^{-6}	NA	2.6×10^{-2}	2.2×10^{-6}	NA	1.9×10^{-2}	2.2×10^{-6}	NA	1.7×10^{-2}	2.2×10^{-6}	NA
Zinc	**4.0**	-	**4.0**	**2.8**	-	**2.8**	**1.9**	-	**1.9**	**1.5**	-	**1.5**
Cr + Cu *	0.21	-	-	0.15	-	-	0.11	-	-	0.09	-	-
Cd + Hg + U *	0.38	-	-	0.29	-	-	0.20	-	-	0.17	-	-

Notes: Values shaded in **bold** exceed the acceptable HQ value of 0.5; only non-carcinogenic COPC are shown.
NA Not appropriate; oral and inhalation TRVs have different endpoints (Table 5.7) and therefore a total HQ value is not calculated
* COPC have the same endpoints for oral exposure (Table 5.7) and therefore HQ values are summed
'-' Toxicity data not available

Table 6.6 Hazard Quotients Calculated for Human Receptors at the Historic Keno Hill Mine Site - Galena Hill Area

COPC	Hazard Quotient - Toddler			Hazard Quotient - Child			Hazard Quotient - Teen			Hazard Quotient - Adult		
	Oral + Dermal	**Inhalation**	**Total**	**Oral + Dermal**	**Inhalation**	**Total**	**Oral + Dermal**	**Inhalation**	**Total**	**Oral + Dermal**	**Inhalation**	**Total**
Antimony	0.12	7.8x10^{-7}	NA	8.7x10^{-2}	7.8x10^{-7}	NA	6.4x10^{-2}	7.8x10^{-7}	NA	5.6x10^{-2}	7.8x10^{-7}	NA
Barium	0.10	-	0.10	7.6x10^{-2}	-	7.6x10^{-2}	5.4x10^{-2}	-	5.4x10^{-2}	5.0x10^{-2}	-	5.0x10^{-2}
Cadmium	0.15	-	0.15	0.11	-	0.11	0.08	-	8.0x10^{-2}	6.8x10^{-2}	-	6.8x10^{-2}
Chromium	0.19	-	0.19	0.14	-	0.14	0.10	-	0.10	0.09	-	0.09
Cobalt	8.9x10^{-2}	1.3x10^{-6}	NA	6.8x10^{-2}	1.3x10^{-6}	NA	4.7x10^{-2}	1.3x10^{-6}	NA	4.2x10^{-2}	1.3x10^{-6}	NA
Copper	2.6x10^{-2}	-	2.6x10^{-2}	1.5x10^{-2}	-	1.5x10^{-2}	1.0x10^{-2}	-	1.0x10^{-2}	7.6x10^{-3}	-	7.6x10^{-3}
Lead	0.31	-	0.31	0.22	-	0.22	0.16	-	0.16	0.15	-	0.15
Manganese	7.4x10^{-2}	-	7.4x10^{-2}	6.0x10^{-2}	-	6.0x10^{-2}	4.0x10^{-2}	-	4.0x10^{-2}	3.1x10^{-2}	-	3.1x10^{-2}
Mercury	8.5x10^{-2}	2.4x10^{-8}	8.5x10^{-2}	6.7x10^{-2}	2.4x10^{-8}	6.7x10^{-2}	4.7x10^{-2}	2.4x10^{-8}	4.7x10^{-2}	3.9x10^{-2}	2.4x10^{-8}	3.9x10^{-2}
Molybdenum	3.4x10^{-3}	-	3.4x10^{-3}	2.6x10^{-3}	-	2.6x10^{-3}	1.5x10^{-3}	-	1.5x10^{-3}	1.3x10^{-3}	-	1.3x10^{-3}
Nickel	7.1x10^{-2}	9.5x10^{-5}	NA	5.3x10^{-2}	9.5x10^{-5}	NA	3.8x10^{-2}	9.5x10^{-5}	NA	3.2x10^{-2}	9.5x10^{-5}	NA
Selenium	0.28	-	0.28	0.21	-	0.21	0.15	-	0.15	0.14	-	0.14
Silver	1.1x10^{-2}	-	1.1x10^{-2}	7.9x10^{-3}	-	7.9x10^{-3}	5.8x10^{-3}	-	5.8x10^{-3}	5.1x10^{-3}	-	5.1x10^{-3}
Strontium	9.6x10^{-3}	-	9.6x10^{-3}	7.4x10^{-3}	-	7.4x10^{-3}	5.2x10^{-3}	-	5.2x10^{-3}	4.5x10^{-3}	-	4.5x10^{-3}
Thallium	**1.7**	-	**1.7**	**1.2**	-	**1.2**	**0.90**	-	**0.90**	**0.76**	-	**0.76**
Uranium	2.7x10^{-2}	-	2.7x10^{-2}	1.9x10^{-2}	-	1.9x10^{-2}	1.4x10^{-2}	-	1.4x10^{-2}	1.3x10^{-2}	-	1.3x10^{-2}
Vanadium	7.3x10^{-2}	2.2x10^{-6}	NA	5.3x10^{-2}	2.2x10^{-6}	NA	3.8x10^{-2}	2.2x10^{-6}	NA	3.3x10^{-2}	2.2x10^{-6}	NA
Zinc	**3.7**	-	**3.7**	**2.7**	-	**2.7**	**1.8**	-	**1.8**	**1.4**	-	**1.4**
Cr + Cu *	0.22	-	-	0.16	-	-	0.11	-	-	0.10	-	-
Cd + Hg + U *	0.26			0.20			0.14			0.12		

Notes: Values shaded in **bold** exceed the acceptable HQ value of 0.5; only non-carcinogenic COPC are shown
NA Not appropriate; oral and inhalation TRVs have different endpoints (Table 5.7) and therefore a total HQ value is not calculated
* COPC have the same endpoints for oral exposure (Table 5.7) and therefore HQ values are summed
'-' Toxicity data not available

6.2.2 Carcinogenic Effects

For carcinogenic COPC, an incremental risk is calculated by multiplying the estimated dose (in mg/kg-d) by the appropriate slope factor (in $(mg/(kg\text{-}d))^{-1}$) for dermal (soil) and oral exposures and the amortized air concentration (mg/m^3) by the appropriate unit risk (in $(mg/m^3)^{-1}$) for inhalation. This is shown in Equation 6-3. The estimate corresponds to an incremental risk of an individual developing cancer over a lifetime as a result of exposure. Risk is defined as follows:

$$Risk_{o/d} = \left(I_{soil} + I_{water} + I_{food}\right) \times TRV_o + \left(I^{s}_{dermal} \times TRV_d\right) \qquad (6\text{-}3)$$

$$Risk_i = C_{air} \times F_{site} \times \frac{ED}{LE} \times TRV_i$$

Where:

$Risk_{o/d}$	=	Incremental risk level – oral and dermal exposure [-]
$Risk_i$	=	Incremental risk level – inhalation exposure [-]
C_{air}	=	Concentration of COPC in air [mg/m^3]
F_{site}	=	Fraction of time at site [-]
ED	=	Total years exposed to site [y]
LE	=	Life expectancy [y]
I_{soil}	=	Intake of COPC through the ingestion of soil pathway [mg/(kg-d)]
I_{water}	=	Intake of COPC through the ingestion of water pathway [mg/(kg-d)]
I_{food}	=	Intake of COPC through the ingestion of food pathway [mg/(kg-d)]
I^{s}_{dermal}	=	Intake of COPC in soil through the dermal pathways [mg/(kg-d)]
TRV_o	=	Toxicological Reference Value for carcinogenic effects from oral exposure [$(mg/(kg\text{-}d))^{-1}$]
TRV_d	=	Toxicological Reference Value for carcinogenic effects from dermal exposure [$(mg/(kg\text{-}d))^{-1}$] (assumed equal to TRV_o)
TRV_i	=	Toxicological Reference Value for carcinogenic effects from inhalation [$mg/m^3]^{-1}$

The calculated risk is then compared to acceptable benchmarks. In this assessment, an incremental risk level of 1 x 10^{-5} (1 in 100,000) was used to assess carcinogenic effects. Health Canada considers this value to represent an "essentially negligible" risk. Risk levels for the toddler, child and teen receptors are generally not calculated since the exposure of these receptors is not sufficient for carcinogenic effects to be observed. As such, a composite receptor is assessed, who encompasses the exposure over a receptor over a lifetime (i.e., 80 years).

Again, the doses or intakes for the different pathways of exposure were presented in Section 4.4.2 for the toddler (results for all age groups are presented in Appendix B) and the TRVs used in this assessment were discussed in Section 5.2.

The risk levels calculated for the adult and composite receptors at both the South McQuesten and Galena Hill areas are presented in Table 6.7 and Table 6.8, respectively. It should be noted that these risks represent total risks and not incremental risks since background exposures are also included in the calculations. Thus the comparison to the Health Canada "essentially negligible" incremental risk level of 1 x 10^{-5} (i.e., 1 in 100,000) is not appropriate.

As seen in the tables, total risks for the composite and adult receptors at both areas are largely as a result of oral ingestion and dermal contact with arsenic. Ingestion of moose is the dominant exposure pathway. Literature feed-to-flesh TFs are used to estimate moose flesh concentrations, which likely results in an overestimate of exposures and risks. This is supported by data from moose captured at the Faro Mine. The predicted concentration of arsenic in moose flesh is 0.09 mg/kg ww and the measured concentrations in the kidney and liver samples obtained from two moose from the Keno Hill area are both 0.005 mg/kg ww. Arsenic concentrations in kidney and liver from moose captured at the Faro Mine are similar (0.002 mg/kg ww for liver and 0.01 mg/kg ww for kidney), and the measured concentration in flesh was 0.002 mg/kg ww. Similar to the discussion for zinc above, the measured arsenic concentration in moose flesh suggests that the predicted concentrations in the assessment may be overestimated by a factor of 45. If the measured arsenic concentrations in moose flesh from the Faro Mine are used in lieu of the estimated values, the total risk from arsenic decreases (for the South McQuesten area the risk decreases from 3.9×10^{-4} to 2.1×10^{-4}). These results support the recommendation to collect moose flesh data in order to verify the results of the risk assessment.

Inhalation of arsenic, cadmium chromium and nickel adsorbed to soil particulates contributes negligibly to the total risks.

Table 6.7 Total Risk Levels Calculated for Human Receptors at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Risk Level - Adult			Risk Level - Composite		
	Oral + Dermal	Inhalation	Total	Oral + Dermal	Inhalation	Total
Arsenic	2.7×10^{-4}	4.6×10^{-8}	2.7×10^{-4}	3.9×10^{-4}	5.9×10^{-8}	3.9×10^{-4}
Cadmium	-	1.0×10^{-8}	1.0×10^{-8}	-	1.3×10^{-8}	1.3×10^{-8}
Chromium	-	1.2×10^{-8}	1.2×10^{-8}	-	1.6×10^{-8}	1.6×10^{-8}
Nickel	-	1.1×10^{-8}	1.1×10^{-8}	-	1.4×10^{-8}	1.4×10^{-8}

Notes: Only carcinogenic COPC are presented; background is included in the calculation therefore values are not compared to a threshold incremental risk level

'-' Not considered to be carcinogenic *via* this pathway

Table 6.8 Total Risk Levels Calculated for Human Receptors at the Historic Keno Hill Mine Site - Galena Hill Area

COPC	Risk Level - Adult			Risk Level - Composite		
	Oral + Dermal	Inhalation	Total	Oral + Dermal	Inhalation	Total
Arsenic	$3.3x10^{-4}$	$8.6x10^{-9}$	$3.3x10^{-4}$	$4.8x10^{-4}$	$1.1x10^{-8}$	$4.8x10^{-4}$
Cadmium	-	$1.3x10^{-9}$	$1.3x10^{-9}$	-	$1.7x10^{-9}$	$1.7x10^{-9}$
Chromium	-	$1.2x10^{-8}$	$1.2x10^{-8}$	-	$1.5x10^{-8}$	$1.5x10^{-8}$
Nickel	-	$1.9x10^{-9}$	$1.9x10^{-9}$	-	$2.5x10^{-9}$	$2.5x10^{-9}$

Notes: Only carcinogenic COPC are presented; background is included in the calculation therefore values are not compared to a threshold incremental risk level

'-' Not considered to be carcinogenic *via* this pathway

6.3 SENSITIVITY ANALYSIS

As discussed in Section 4.3, when measured concentrations in environmental media were not available, transfer factors (TFs) were used to estimate concentrations. For fish, site-specific water-to-fish TFs were calculated when sufficient data were available, and in general these values were similar to literature values. The exception to this was zinc. The calculated average site-specific water-to-fish TF was 250 L/(kg ww) while the value from the IAEA (2010) was 3400 L/(kg ww). The site-specific value was used in the assessment, but a sensitivity analysis was conducted in order to determine the potential impact on the results of the assessment.

Measured fish data were available for all areas evaluated with the exception of the Silver King area. If the IAEA (2010) TF for zinc of 3400 L/(kg ww) is used in the assessment instead of the site-specific value, then the SI value for mink, which consumes fish from the Silver King area, increases from 0.07 to 0.2. This SI value is still well below the SI benchmark value of 1.0 and the conclusions related to zinc remain unchanged. The human health assessment is not affected since receptors were not assumed to ingest fish from the Silver King area.

As discussed in Section 3.2.3, measured data on concentrations of COPC in Labrador tea were used to estimate intake by human receptors from consumption of medicinal tea. Receveur *et al.* (1998) also provides frequencies and percents of the study group consuming other medicinal plants, such as birch and willow. Data were not available specifically for the parts of these plants typically consumed by FNNND, such as sap and inner bark; however, a sensitivity analysis was conducted using the data that were available for these species. From Table 6.9, it can be seen that for most COPC the measured concentrations in Labrador tea are similar to those in browse; however, for some COPC the concentrations in browse are higher. It should be noted that the calculated HQ values remain unchanged since consumption of medicinal tea is such a small pathway in comparison to other exposure routes (generally less than 1%). As such, the use of

Labrador tea data in lieu of birch and willow data for medicinal tea does not affect the results of the risk assessment.

Table 6.9 Comparison of Measured Data in Labrador Tea and Browse

COPC	Galena Hill (mg/kg ww)		South McQuesten (mg/kg ww)	
	Labrador Tea	Browse	Labrador Tea	Browse
Antimony	0.02	0.02	0.02	0.02
Arsenic	0.02	0.02	0.02	0.02
Barium	9.4	56	36	17
Cadmium	0.003	0.78	0.004	0.53
Chromium	0.02	0.02	0.10	0.07
Cobalt	0.02	0.22	0.02	0.21
Copper	0.02	0.34	1.4	0.79
Lead	0.03	0.05	0.06	0.07
Manganese	108	110	143	155
Mercury	0.002	0.002	0.002	0.002
Molybdenum	0.02	0.03	0.03	0.07
Nickel	0.11	0.60	0.18	0.67
Selenium	0.03	0.03	0.04	0.06
Silver	0.002	0.002	0.002	0.002
Strontium	1.5	11.2	2.2	6.5
Thallium	0.01	0.003	0.01	0.004
Uranium	0.006	0.006	0.007	0.007
Vanadium	0.08	0.08	0.09	0.08
Zinc	3.2	24	13	47

In the risk assessment it has been assumed that humans only consume the flesh of animals and not the organs. For the moose, measured data were available from kidney and liver samples from two moose obtained from the Keno Hill area in 2009 and 2010 (Table 2.14). A sensitivity analysis was conducted using these measured concentrations to determine the effect of organ consumption on the assessment.

The Yukon dietary survey (Receveur *et al.* 1998) indicates that about 25% of the population consumes moose liver and kidneys 0.3 to 0.4 days per week. It has been assumed that only adults consume the organs. There is little information provided on how much organ meat an individual may consume. From the dietary survey, it was reported that 1 individual consumed 112 g of moose liver, which is about ½ a moose meat portion and about the same portion of someone consuming dry moose meat. Therefore, for the purposes of the sensitivity analysis, it was assumed that people would consume about 112 g of liver or kidneys 0.35 days per week over the course of a year (i.e., 5.6 g/d). Using the measured concentrations of COPC provided in Table 2.14, results of the intakes of COPC are presented in Table 6.10 for an adult human receptor in the South McQuesten area. The table also provides a comparison with the predicted intakes from the other dietary pathways. The percent contribution from each pathway is presented in Table 6.11.

From Table 6.10 and Table 6.11 it can be seen that, with the exception of cadmium concentrations in moose kidney and copper and molybdenum concentrations in moose liver, the intake of COPC through the ingestion of moose kidney and liver is much less than the ingestion of COPC through other ingestion routes. For cadmium, the intake from moose kidney is larger than the intake through other ingestion pathways. It is known that cadmium accumulates in the liver and kidneys and thus it is not unusual that high levels of cadmium would be found in the kidneys of moose. Therefore, consumption of moose kidneys should only occur on an occasional basis, as should consumption of moose liver.

The effect of consideration of moose organ consumption in the risk characterization step is summarized in Table 6.12. As seen from this table, with the exception of cadmium exposure, consideration of organ consumption does not materially alter the risk assessment.

Table 6.10 Predicted Intakes for Human Receptors Considering Moose Organs

COPC	Intake for Adult in South McQuesten Area (mg/(kg-d))						
	Moose Kidney	Moose Liver	Other Ingestion	Total Ingestion	Dermal	Air	Total Intake
Antimony	$2.0x10^{-7}$	$3.6x10^{-7}$	$5.3x10^{-5}$	$5.4x10^{-5}$	$5.5x10^{-7}$	$4.1x10^{-10}$	$5.4x10^{-5}$
Arsenic	$2.0x10^{-7}$	$2.0x10^{-6}$	$2.0x10^{-4}$	$2.0x10^{-4}$	$8.9x10^{-7}$	$2.2x10^{-9}$	$2.0x10^{-4}$
Barium	$1.7x10^{-5}$	$8.6x10^{-6}$	$5.4x10^{-4}$	$5.7x10^{-4}$	$6.4x10^{-6}$	$4.7x10^{-9}$	$5.7x10^{-4}$
Cadmium	$6.9x10^{-4}$	$3.4x10^{-4}$	$8.9x10^{-5}$	$1.1x10^{-3}$	$4.3x10^{-8}$	$3.2x10^{-10}$	$9.2x10^{-5}$
Chromium	$5.9x10^{-6}$	$3.6x10^{-6}$	$8.2x10^{-5}$	$9.2x10^{-5}$	$4.7x10^{-7}$	$3.5x10^{-10}$	$4.5x10^{-4}$
Cobalt	$2.1x10^{-6}$	$1.0x10^{-5}$	$3.2x10^{-5}$	$4.4x10^{-5}$	$9.0x10^{-7}$	$6.7x10^{-10}$	$4.5x10^{-5}$
Copper	$9.4x10^{-5}$	$2.8x10^{-3}$	$1.1x10^{-3}$	$4.0x10^{-3}$	$6.2x10^{-7}$	$7.6x10^{-10}$	$4.0x10^{-3}$
Lead	$9.1x10^{-7}$	$7.1x10^{-7}$	$7.6x10^{-4}$	$7.6x10^{-4}$	$5.7x10^{-7}$	$6.9x10^{-9}$	$7.6x10^{-4}$
Manganese	$3.4x10^{-5}$	$8.2x10^{-5}$	$7.3x10^{-3}$	$7.4x10^{-3}$	$7.5x10^{-5}$	$5.5x10^{-8}$	$7.5x10^{-3}$
Mercury	$3.0x10^{-7}$	$5.6x10^{-7}$	$2.2x10^{-5}$	$2.3x10^{-5}$	$1.7x10^{-9}$	$1.2x10^{-12}$	$2.3x10^{-5}$
Molybdenum	$5.1x10^{-6}$	$3.5x10^{-5}$	$5.9x10^{-5}$	$1.0x10^{-4}$	$3.2x10^{-9}$	$2.4x10^{-11}$	$1.0x10^{-4}$
Nickel	$2.0x10^{-6}$	$3.6x10^{-6}$	$5.3x10^{-4}$	$5.4x10^{-4}$	$2.9x10^{-6}$	$2.5x10^{-9}$	$5.4x10^{-4}$
Selenium	$2.4x10^{-5}$	$5.3x10^{-5}$	$4.6x10^{-4}$	$5.3x10^{-4}$	$4.7x10^{-9}$	$3.5x10^{-11}$	$5.3x10^{-4}$
Silver	-	-	$2.9x10^{-5}$	$2.9x10^{-5}$	$5.4x10^{-7}$	$1.6x10^{-10}$	$3.0x10^{-5}$
Strontium	$6.3x10^{-6}$	$2.4x10^{-6}$	$1.9x10^{-3}$	$1.9x10^{-3}$	$1.3x10^{-6}$	$9.2x10^{-10}$	$1.9x10^{-3}$
Thallium	$2.0x10^{-7}$	$2.1x10^{-7}$	$1.5x10^{-5}$	$1.5x10^{-5}$	$2.0x10^{-10}$	$1.5x10^{-12}$	$1.5x10^{-5}$
Uranium	$4.0x10^{-8}$	$7.1x10^{-8}$	$7.9x10^{-6}$	$8.0x10^{-6}$	-	-	$8.0x10^{-6}$
Vanadium	$2.0x10^{-6}$	$3.6x10^{-6}$	$8.2x10^{-5}$	$8.8x10^{-5}$	$7.1x10^{-7}$	$5.2x10^{-10}$	$8.8x10^{-5}$
Zinc	$1.0x10^{-3}$	$9.9x10^{-4}$	$8.5x10^{-1}$	$8.5x10^{-1}$	$3.2x10^{-5}$	$2.4x10^{-8}$	$8.5x10^{-1}$

Notes:

'-' No data available

Table 6.11 Percentage of Intakes for Human Receptors Considering Moose Organs

COPC	Ingestion for Adult in South McQuesten Area					
	Moose Kidney	Moose Liver	Other Ingestion	Total Ingestion	Dermal	Air
Antimony	0.4%	0.7%	98%	99%	1.0%	<0.01%
Arsenic	0.1%	1.0%	98%	100%	0.5%	<0.01%
Barium	2.9%	1.5%	94%	99%	1.1%	<0.01%
Cadmium	61%	31%	8%	100%	<0.01%	<0.01%
Chromium	6.4%	3.9%	89%	100%	0.1%	<0.01%
Cobalt	4.7%	23%	70%	98%	2.0%	<0.01%
Copper	2.4%	71%	26%	100%	0.02%	<0.01%
Lead	0.1%	0.1%	100%	100%	0.1%	<0.01%
Manganese	0.5%	1.1%	97%	99%	1.0%	<0.01%
Mercury	1.3%	2.5%	96%	100%	0.01%	<0.01%
Molybdenum	5.1%	35%	60%	100%	<0.01%	<0.01%
Nickel	0.4%	0.7%	98%	99%	0.5%	<0.01%
Selenium	4.5%	9.9%	86%	100%	<0.01%	<0.01%
Silver	-	-	98%	98%	1.8%	<0.01%
Strontium	0.3%	0.1%	99%	100%	0.1%	<0.01%
Thallium	1.4%	1.5%	97%	100%	<0.01%	<0.01%
Uranium	0.5%	0.9%	99%	100%	-	-
Vanadium	2.2%	4.0%	93%	99%	0.8%	<0.01%
Zinc	0.1%	0.1%	100%	100%	<0.01%	<0.01%

Notes: '-' No data available

Table 6.12 Comparison of Hazard Quotients With and Without Organ Consumption

COPC	Without Organ Consumption			With Organ Consumption		
	Oral + Dermal	Inhalation	Total	Oral + Dermal	Inhalation	Total
Antimony	0.13	$8.7x10^{-6}$	NA	0.14	$8.7x10^{-6}$	NA
Barium	$3.4x10^{-2}$	-	$3.4x10^{-2}$	$3.6x10^{-2}$	-	$3.6x10^{-2}$
Cadmium	$8.9x10^{-2}$	-	$8.9x10^{-2}$	**1.1**	-	**1.1**
Chromium	$9.0x10^{-2}$	-	$9.0x10^{-2}$	$9.0x10^{-2}$	-	$9.0x10^{-2}$
Cobalt	$3.3x10^{-2}$	$5.7x10^{-6}$	NA	$4.5x10^{-2}$	$5.7x10^{-6}$	NA
Copper	$7.5x10^{-3}$	-	$7.5x10^{-3}$	$2.8x10^{-2}$	-	$2.8x10^{-2}$
Lead	0.21	-	0.21	0.21	-	0.21
Manganese	$4.7x10^{-2}$	-	$4.7x10^{-2}$	$4.8x10^{-2}$	-	$4.8x10^{-2}$
Mercury	$7.2x10^{-2}$	$1.7x10^{-8}$	$7.2x10^{-2}$	$7.5x10^{-2}$	$1.7x10^{-8}$	$7.5x10^{-2}$
Molybdenum	$2.1x10^{-3}$	-	$2.1x10^{-3}$	$3.6x10^{-3}$	-	$3.6x10^{-3}$
Nickel	$4.9x10^{-2}$	$5.3x10^{-4}$	NA	$4.9x10^{-2}$	$5.3x10^{-4}$	NA
Selenium	$8.0x10^{-2}$	-	$8.0x10^{-2}$	$9.4x10^{-2}$	-	$9.4x10^{-2}$
Silver	$5.9x10^{-3}$	-	$5.9x10^{-3}$	$5.9x10^{-3}$	-	$5.9x10^{-3}$
Strontium	$3.2x10^{-3}$	-	$3.2x10^{-3}$	$3.2x10^{-3}$	-	$3.2x10^{-3}$
Thallium	**1.0**	-	**1.0**	**1.1**	-	**1.1**
Uranium	$1.3x10^{-2}$	-	$1.3x10^{-2}$	$1.3x10^{-2}$	-	$1.3x10^{-2}$
Vanadium	$1.7x10^{-2}$	$2.2x10^{-6}$	NA	$1.8x10^{-2}$	$2.2x10^{-6}$	NA
Zinc	**1.5**	-	**1.5**	**1.5**	-	**1.5**

Notes: Values shaded in **bold** exceed the acceptable HQ value of 0.5
NA Not appropriate; oral and inhalation TRVs have different endpoints and therefore a total HQ value is not calculated
'-' Toxicity data not available

6.4 UNCERTAINTIES

Many areas of uncertainty attend a risk assessment. This is due to the fact that assumptions have to be made throughout the assessment either due to data gaps, environmental fate complexities or in the generalization of receptor characteristics. To be able to place a level of confidence in the results, an accounting of the uncertainty, the magnitude and type of which are important in determining the significance of the results, must be completed. In recognition of these uncertainties, conservative assumptions were used throughout the assessment to ensure that the potential for an adverse effect would not be underestimated. The major assumptions are outlined below.

The measured COPC concentrations used in the assessment were based on data from the aquatic and terrestrial environments from a variety of previous sampling programs and environmental assessments. The site characterization data collection process is biased toward determining and delineating areas of contamination, rather than areas meeting applicable generic standards, which also indicates that these concentrations are a conservative representation of the overall site conditions. Additionally, the use of reasonable maximum exposure concentrations, which were generally maximum measured or 95% UCLM values, tend to overestimate exposures since receptors are mobile and will not be exposed to the maximum concentrations for the entire time on site.

In the absence of measured data, transfer factors (TFs), for the most part based on literature, were used to estimate concentrations. There is some uncertainty involved in the use of TFs; however, in the absence of measured data, TFs provide the only method for estimating concentrations and for estimating transfer up the food chain. As indicated in the human health assessment, the feed-to-flesh transfer factor for zinc for mammals (moose in particular) results in an over-prediction of the muscle concentration by at least a factor of eight.

The ecological exposure profiles are a source of uncertainty, as receptors adjust and vary their diet according to the food sources available. The characteristics (e.g., body weight, food and soil consumption) of ecological receptors were obtained from the literature. These values are generally obtained from animals in captivity and may not be fully representative of free-range animals in the wild. An underestimate of exposure might result from this but there are other conservative assumptions that may compensate (e.g. time spent in area exposed to site contamination).

Similarly, the Yukon dietary survey (Receveur *et al* 1998) was used to characterize the exposure to humans. This survey is based on a 24-hour recall. The use of a 24-hour recall may overestimate exposures for some food items and underestimate exposures for other food items.

Toxicological Reference Values (TRVs) are obtained from reputable sources (e.g., Health Canada, U.S. EPA, etc.); nonetheless, they are always associated with uncertainty due to the extrapolation of testing on lab species (e.g., rats) to field conditions as well as a range of receptors. Additionally, toxicity information for a COPC was used regardless of its form in the test procedure, even though this may not be the same form used in the assessment (e.g., an oxide form compared to a more soluble form). It is difficult to determine the effect of these assumptions. Additional uncertainty comes from the lack of avian TRVs for some metals included in this assessment as COPC.

Another area of uncertainty is the use of a single value for toxicity. Slope factors and unit risks are selected to be very protective, and the reference doses represent an exposure day-after-day for a lifetime. The use of an upper bound for the toxicity values ensures that the risk to humans is not underestimated. This was demonstrated for thallium in Section 6.2.1 when the selection of one TRV over another as the RfD was shown to impact the results of the assessment significantly

It is currently not possible or practical to develop approaches to evaluate the validity of the toxicity benchmark assumptions on the overall assessment. As improvements occur in toxicological/human health research and assessments, the uncertainties may be reduced.

The amount of Labrador tea (leaves and stems) used to brew medicinal tea and the amount of tea consumed was assumed as the Yukon dietary survey (Receveur *et al.* 1998) did not provide this information. This leads to uncertainty in the assessment. As the consumption of Labrador tea only represented a small fraction (generally less than 1%) of the intake for most of the COPC it is unlikely that the uncertainty in the consumption of Labrador tea would change the results of the assessment. This is supported by the sensitivity analysis discussed in the previous section.

Another area of uncertainty in the risk assessment is the effect of multiple COPC. When dealing with toxic chemicals, there is potential interaction with other chemicals that may be found at the same location. It is well established that synergism, potentiation, antagonism or additivity of toxic effects occurs in the environment. A quantitative assessment of these interactions is outside the scope of this study and, in any event, would be constrained, as there is not an adequate base of toxicological evidence to quantify these interactions. This may result in an underestimate of the risk for some COPC.

Table 6.13 provides a summary of the uncertainties discussed above. It can be seen from the table that, in general, the uncertainties lead to an over-estimate of exposures and thus the conclusions of the assessment would remain unchanged.

Table 6.13 Summary of Uncertainties in the HHERA

Uncertainty	Likely Leads to Overestimate	Possibly Leads to Underestimate	Neither Overestimate or Underestimate
Use of site-specific and literature transfer factors in the absence of measured data	X		
Biased sampling towards impacted areas	X		
Use of reasonable maximum exposure concentrations to characterize exposures	X		
Use of literature characteristics for ecological receptors		X	
Exposure assumptions – exclusively on site	X		
Single value for toxicity for receptors	X		
Assumption for the consumption of Labrador tea			X
Synergism, potentiation, antagonism, additivity of toxic effects		X	
Absence of avian toxicity data		X	

7.0 SUMMARY AND CONCLUSIONS

The historic Keno Hill Mine site is located approximately 330 km north of Whitehorse, Yukon. It comprises approximately 23,350 hectares (ha) of mining leases, quartz claims and crown grants and has numerous mineral occurrences, deposits and prospects, including 35 mines with a history of production. Mining activities at the site ceased in 1989, but the surrounding environment continues to be impacted by mine drainage water from abandoned adits, buildings/structures, a tailings impoundment area and other waste material. The tributaries that drain the properties include Christal Creek, Flat Creek and Lightning Creek and represent the most significantly impacted areas, although some influence on water and sediment quality has been documented further downstream in the South McQuesten River.

A Human Health and Ecological Risk Assessment (HHERA) was carried out for ecological and human receptors known or expected to be in the area of the historic Keno Hill Mine site to assess the potential risk from exposure to constituents in the terrestrial and aquatic environments. The assessment was based on reasonable maximum likely exposures to the constituents of potential concern (COPC). Receptor characteristics (e.g., proportion of time spent in the study area, source of drinking water) and exposure pathways (e.g. inhalation and ingestion) were taken into consideration. The assumptions made for the risk assessment are intended to err on the side of caution and therefore over-estimating intakes. The level of caution in these assumptions is consistent with the approach typically adopted at this stage.

The results of the aquatic environment assessment are summarized in Table 7.1 for water quality and in Table 7.2 for sediment quality. Only those COPC which resulted in the exceedance of a toxicological reference value are presented. From Table 7.1 it can be seen that concentrations of copper, iron, lead, manganese, silver and zinc result exceed toxicity reference values for fish at a number of locations. Christal Creek at the Outlet of Christal Lake and the Lower South McQuesten River are the areas of exceedances for most of the COPC. Zinc concentrations exceed toxicity reference values at most of the locations. It should be noted that zinc concentrations also exceed the toxicity reference values at the background locations. However, the results of the aquatic assessment support that zinc is a key constituent of concern in the aquatic environment. Zinc levels in fish tissue are elevated in most of the mining affected waters. For example, sculpins from the Keno Hill area have zinc levels much greater than sculpins captured near the tailings discharge area at the Faro Mine site. However, fish studies have found that there are no clear differences in overall fish species diversity between mine-exposed and reference areas since average relative fish abundance at all mine-exposed creeks and areas downstream of the South McQuesten River were similar to or higher than the reference area. Thus, the elevated COPC levels in the water bodies in the Keno Hill area are not adversely affecting fish populations.

Table 7.1 Results of Aquatic Assessment - Water Quality

COPC	Location											
	LC	**CC at Outlet of CL**	**CC d/s of CL**	**Upper SMQR**	**Lower SMQR**	**BC/FC u/s of adits**	**BC/FC d/s of adits**	**GC u/s of adit**	**GC d/s of adit**	**NCC**	**SaC/ StC**	**Bkgd**
Cadmium	-	ZP, PF	ZP	-	ZP	PP, ZP	ZP	-	ZP	PP, ZP	PP, ZP	-
Chromium	AP	-	-	-	-	AP	AP	-	AP	-	AP	-
Copper	PP, ZP, PF, FF	PP, ZP	-	PP, ZP	PP, ZP	PP, ZP	PP, ZP	PP, ZP	PP, ZP	PP, ZP	PP, ZP	-
Iron	ZP, FF	ZP, FF	FF	FF	FF	ZP	ZP	-	ZP	-	ZP	-
Lead	BI, ZP, PF	BI, ZP	-	-	BI, ZP, PF	-	-	BI, ZP	-	BI, ZP	-	-
Manganese	-	PF	-	-	-	ZP	ZP	-	-	-	-	-
Silver	ZP	ZP	-	-	ZP, PF, FF	-	-	ZP	-	-	-	-
Zinc	-	PP, BI, ZP, PF, FF	PP, BI, ZP, PF, FF	PP, ZP, PF, FF	PP, ZP, PF, FF	PP, BI, ZP	PP, BI, ZP	-	PP, ZP	PP, BI, ZP	PP, BI, ZP	PP, ZP, PF, FF

Notes: Only those COPC with SI values exceeding one or more benchmarks are presented

AP	Aquatic plants	LC	Lightning Creek	GC	Galena Creek
BI	Benthic invertebrates	CC	Christal Creek	NCC	No Cash Creek
FF	Forage fish	CL	Christal Lake	SaC	Sandy Creek
PF	Predator fish	SMQR	South McQuesten River	StC	Star Creek
PP	Phytoplankton	BC	Brefault Creek	Bkgd	Background
ZP	Zooplankton	FC	Flat Creek		

From Table 7.2 it can be seen that sediment toxicity benchmarks are exceeded for arsenic, cadmium, lead and zinc at all locations that were evaluated. Arsenic and cadmium sediment concentrations in background also exceed sediment toxicity benchmarks. Even though, the sediment toxicity benchmarks have been exceeded at South McQuesten River and Lightning Creek, benthic community surveys have reported healthy communities in these two locations. Low numbers and diversity have however been documented in Flat and Christal creeks, suggesting that high concentrations of COPC in sediments in these creeks may be adversely affecting benthic communities.

Table 7.2 Results of Aquatic Assessment - Sediment Quality

COPC	Location					
	LC	CC at Outlet of CL	CC d/s of CL	Upper SMQR	Lower SMQR	Bkgd
Arsenic	X	X	X	X	X	X
Cadmium	X	X	X	X	X	X
Lead	X	X	X	X	X	✓
Zinc	X	X	X	X	X	✓

Notes: Only those COPC with SI values exceeding the CCME (2011) Probable Effect Level (PEL) and/or the Thompson *et al.* (2005) Severe Effect Level (SEL) are shown.

X Indicates exceedance of a sediment toxicity benchmark

✓ Indicates no exceedance of sediment toxicity benchmarks

LC Lightning Creek CL Christal Lake Bkgd Background

CC Christal Creek SMQR South McQuesten River

An assessment was also carried out for ecological receptors present in the terrestrial environment. The receptors that were considered were avian species such as grouse and waterfowl and mammalian species such as small mammals (beaver [aquatic-based diet], fox, hare, marmot and mink [aquatic-based diet]) and larger animals (bear, caribou, moose, sheep and wolf). The larger animals were evaluated on a site-wide basis and smaller animals were assumed to be present at various locations across the Keno Hill area. The results of the assessment are summarized in Table 7.3. As seen from the table, there are no issues for large mammals that are present at the site. Waterfowl that consume mainly benthic invertebrates and sediments (scaup) as well as beaver may be exposed to elevated levels of arsenic, lead and selenium from Christal Creek and Christal Lake. However, populations of these species will not be adversely affected due to the small spatial area. The maximum measured concentration of cadmium in browse results in unacceptable exposures for beaver and hare at the Mackeno Tailings area. Only four samples were collected with cadmium concentrations ranging from 0.31 to 16.6 mg/kg ww. The large range suggests that more browse data may be needed to verify the results of the assessment. Nonetheless, it is not expected that beaver and hare populations would be adversely affected by the elevated cadmium concentrations in browse due to the small spatial extent of the Mackeno Tailings area.

Table 7.3 Results of Terrestrial Assessment

COPC	Location					
	GH	MT	VT	SK	SMQ	UKHM
Arsenic	Mink	Scaup, Beaver	Hare	Mink	Mink	Scaup, Beaver
Cadmium	-	Beaver, Hare	-	-	-	Beaver, Hare
Lead	-	Scaup	-	-	-	Scaup
Selenium	Mink	-	-	-	Mink	-
Zinc	-	Scaup	-	-	-	Scaup

Notes: Only those COPC with SI values exceeding the benchmark values are shown.
'-' Indicates no exceedance of HQ benchmark value for any of the receptors
GH Galena Hill VT Valley Tailings UKHM Entirety of site
MT Mackeno Tailings SMQ South McQuesten

A human health assessment was carried out for hypothetical individuals being present at Galena Hill and the South McQuesten River area. Individuals were assumed to be present in these areas for 1.5 months of the year and hunt, trap, gather and fish and consume the food obtained over a six month period. Different life stages were evaluated ranging from a toddler to an adult. There are a few year-round residents who have been implicitly evaluated in the assessment given that it was assumed that traditional food was consumed over a 6 month period. The results of the assessment indicated that transfer factors used to determine arsenic and zinc concentrations in moose may be over predicting moose tissue concentrations. Measured arsenic concentrations in liver and kidney of moose from the Keno Hill area are similar to those from the Faro Mine site; however the predicted zinc and arsenic concentrations in muscle tissue are 9 to 40 times higher than the measured concentrations in tissue from the Faro Mine site. Therefore it is recommended that moose muscle samples be collected from the area and analyzed to verify the results of the risk assessment. In addition, the assessment demonstrated that consumption of cadmium in moose organs can potentially lead to unacceptable exposures and therefore consumption of moose kidneys and livers should only occur on an occasional basis (i.e., one time per month).

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APPENDIX A

SELECTION OF COPC

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APPENDIX A: SELECTION OF CONSTITUENTS OF POTENTIAL CONCERN

A selection process was performed to identify Constituents of Potential Concern (COPC) at the historic Keno Hill Mine site. The following sections describe the process followed for the selection of COPC.

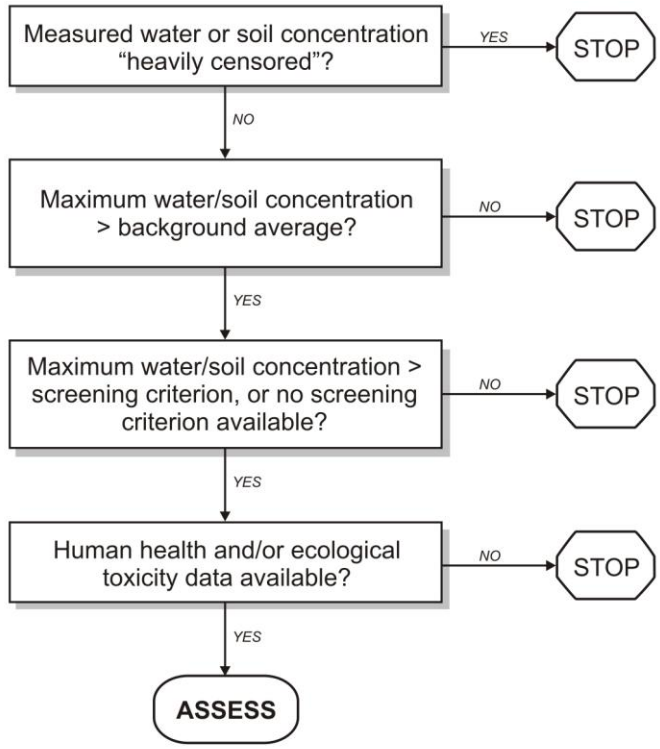
The constituents that were considered for this assessment include: aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), bismuth (Bi), boron (B), cadmium (Cd), calcium (Ca), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb, lithium (Li), magnesium (Mg), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), phosphorus (P), potassium (K), selenium (Se), silicon (Si), silver (Ag), sodium (Na), strontium (Sr), sulphur (S), tellurium (Te), thallium (Tl), thorium (Th), tin (Sn), titanium (Ti), uranium (U), vanadium (V), zinc (Zn) and zirconium (Zr). In addition, ammonia was considered in the aquatic environment. No data are available for the UKHM site on concentrations of organic constituents (i.e., petroleum hydrocarbons, volatile organic compounds, polycyclic aromatic hydrocarbons) in any of the media and therefore these were not considered in the assessment.

A.1 SELECTION PROCESS

A selection process for constituents measured in soil, terrestrial vegetation, surface water and sediment was used to identify the COPC for the risk assessment. In general, the COPC selection process followed the steps outlined in the document entitled *Federal Contaminated Site Risk Assessment in Canada Part V: Guidance on Complex Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRA$_{CHEM}$)), Version 1.0* (Health Canada 2009). The screening process was primarily related to the surface water and soil media with the sediment and terrestrial vegetation screening processes only being used to infill COPC that were not identified in the soil and surface water screens.

The process was essentially a preliminary screening step involving the comparison of measured concentrations to very conservative criteria. The COPC were selected by comparing maximum measured concentrations in each of the media to the Canadian Council of Ministers of the Environment (CCME) guidelines, where available. The process for screening of COPC in surface water and soil is illustrated in Figure A.1. The process for sediment and terrestrial vegetation was similar; however, the methodology differed slightly in that only chemicals with sediment quality criteria or phytotoxic levels were considered further to select additional COPC. If no criteria or phytotoxic levels were available, then those chemicals were not considered further.

Figure A.1 Selection Process for Constituents of Potential Concern



Notes:
"heavily censored" – > 90% of measurements used to calculate the mean were below the MDL

In the first step of the screening process, heavily censored data were identified by calculating the total number of measurements that were below the method detection limit (MDL). If more than 90% of the measured concentrations of samples from an affected area were below the MDL for a constituent, then it was considered that the data for that constituent were heavily censored and the constituent was dropped from further assessment.

The maximum measured concentrations were then compared to background concentrations obtained from reference sites in the study area. If the maximum concentration from an affected area was greater than the background average, then the constituent was not considered to be a COPC.

Those constituents which had maximum measured concentrations above background were then compared to the appropriate screening criteria (i.e., CCME guideline value, where available). Those constituents with maximum measured concentrations below the criteria were dropped from further assessment, while constituents with maximum measured concentrations above the criteria, or with no criteria available, were considered further in the final step.

As the final step, a check was made to determine whether corresponding human health and/or ecological toxicity data are available. Constituents with available toxicity data were selected as

COPC, while those without toxicity data were not further assessed. Although this adds some uncertainty to the assessment, the lack of toxicity data generally denotes constituents that are not considered to be toxic. Therefore, the final COPC list captures the constituents of major concern at the historic Keno Hill Mine site.

The following sections discuss the selection results using the above methodology, for the different environmental media including surface water, sediment, soil and terrestrial vegetation.

A.1.1 Surface Water Screening

Surface water data are available from January 1994 through to August 2009 from impacted water bodies, tailings treatment ponds and adits, as well as reference locations. Measurements from impacted water bodies (e.g., Christal Creek, Flat Creek, South McQuesten River, etc.) in the Keno Hill area from all years were used in the COPC screening assessment. Surface water samples obtained from adits and tailings/treatment ponds were not included in the data used to select COPC as these samples were not considered representative of the site conditions as a whole. Additionally, human and ecological receptors are unlikely to have major pathways of exposure associated with these areas.

Average background concentrations were calculated from the measurements for stations that have previously been considered as reference stations, including KV-1, KV-37, KV-57, KV-60, KV-61, KV-64, KV-65, KV-77, FIEC (Field Creek) and WILC (Williams Creek). Although the concentrations at KV-1 have been found to be increasing since 2007 as a result of an unknown source, KV-1 is the best reference area for the South McQuesten River downstream of the historic Keno Hill Mine site as it represents the upstream conditions prior to mine sources (Minnow 2010).

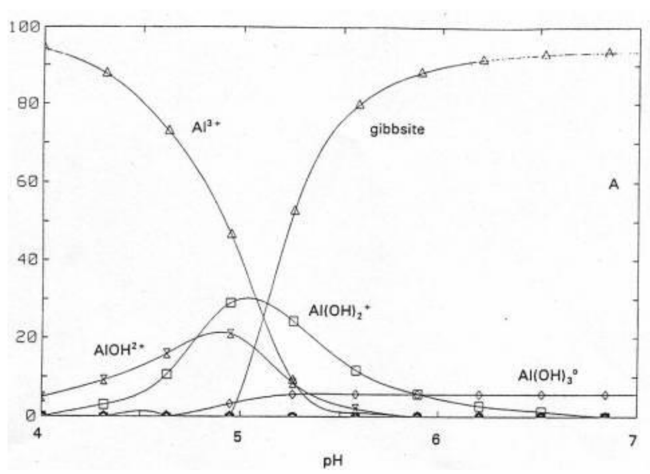
Values below the MDL were converted to ½ the MDL before calculating the average value. Regulatory agencies such as Health Canada, Environment Canada and the U.S. EPA generally consider the use of ½ MDL appropriate since it assumes that on the average all values between the detection limit and zero could be present, and that the average value of non-detects could be as high as half the detection limit. The U.S. EPA indicates that using MDL in risk assessments provides a mean concentration that is biased high and is not consistent with using best science in risk assessments (U.S. EPA 1991).

Table A.1 provides a summary of the data set and selection process for COPC in surface water at the historic Keno Hill Mine site. Surface water measurements taken from the area were assessed collectively, taking the site maximum to be the value of concern. The maximum values were compared to the CCME Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME 2011). In the absence of aquatic life values, guidelines for Canadian Drinking Water Quality (Health Canada 2010) were used.

A large percentage (> 90%) of the measurements of beryllium, bismuth, tellurium, thallium and tin were below the method detection limits; they were thus considered to be heavily censored and were dropped from further assessment. All other constituents had maximum measured concentrations that were greater than the background average and thus no constituents were dropped from the assessment on this basis. Of the remaining constituents, Water Quality Guidelines were not available for calcium, cobalt, magnesium, phosphorus, potassium, silicon, strontium, sulphur, thorium, titanium, vanadium and zirconium. Of these, calcium, magnesium, phosphorus, potassium, silicon, sulphur, thorium, titanium and zirconium were dropped from further assessment due to lack of human health and aquatic toxicological data. Additionally, calcium, magnesium, phosphorus and potassium are considered as natural elements in the earth's crust and are therefore were not considered further.

The maximum measured concentration of aluminum was above the guideline; however, it was not selected as a COPC. Aluminum is complexed by both inorganic and organic ligands in water (see Figure A.2). Below pH of 6, organic complexes and the hydrated free ion tend to be the principal forms. At higher pH, the dissolved species are only a small fraction of the total aluminum present since most of the aluminum is in a particulate form, which is inaccessible and therefore much less toxic than dissolved aluminum. At pH values between 5.5 and 9, there is very little aluminum that is in true solution and available for uptake by biological species (Gardner *et al*. 2002). Since the pH in the aquatic environment in the Keno Hill area is between pH 5.5 and 9 (average of 7.7), the aluminum measured is not in an available (toxic) form and thus aluminum was not considered to be a COPC.

Figure A.2 Aluminum Speciation in Water from pH 4 to 7



Note: from Gensemer and Playle (1999)

Maximum concentrations of antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, uranium and zinc exceed CCME guidelines and were considered to be COPC. While no guidelines exist for cobalt, strontium, and vanadium, aquatic toxicity data do exist and these metals were therefore considered to be COPC. Of the identified COPC, sediment toxicity data are not available for antimony, cobalt, iron, manganese, silver, or strontium.

A.1.2 Sediment Screening

The screening process for sediments was similar to that described above. In the case of sediments, the screening process was only used to identify COPC that may not have been selected in the surface water screening process. If no sediment quality criteria were available, then these constituents were not considered further. Sediment quality data are available for the site from 1985, 1990, 1994, 1997, 2004, 2007, 2008 and 2009. These sampling programs generally focused on collecting data from impacted stations downstream of point sources such as adits (e.g., KV-2 through to KV-9, KV-38, KV-41) and reference stations (e.g., KV-1, KV-37); the 2008 sampling program, however, focused on evaluating sediment quality at fish barriers along Christal Creek downstream of Christal Lake, and near tailings deposits in Christal Lake. Data are not available for smaller tributary watercourses such as those upstream of adits (e.g., KV-59, KV-60, etc.). All sediment measurements from impacted water bodies were assessed collectively, taking the site maximum to be the value of concern.

Background averages were calculated from the measured data from locations KV-1 and KV-37, which have previously been considered to be reference locations. Although, as discussed previously, the concentrations at KV-1 have been increasing since 2007 as a result of an unknown source, KV-1 is the best reference area for the South McQuesten River downstream of the historic Keno Hill Mine site as it represents the upstream conditions prior to mine sources (Minnow 2010). All values below the MDL were converted to ½ the MDL before the average values were calculated.

A comparison was made to the CCME Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME 2011). In the absence of a value from the CCME, sediment criterion values developed by Thompson *et al.* (2005) were used. The results of the sediment screening are presented in Table A.2. Only those constituents for which criterion values are available are presented. The constituents in sediment that satisfied the conditions in all of the selection steps and were considered as COPC are arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, uranium, vanadium and zinc. All COPC were identified in the surface water screening process and no further COPC were added to the list.

A.1.3 Soil Screening

Previous environmental monitoring has focussed on the aquatic environment, and it is only in recent years that the terrestrial environment (soil, vegetation) has been evaluated. The only soil quality data available were obtained in 2009, and are from the tailings disturbance area directly around the Elsa tailings, two areas potentially impacted by water discharge from mine adits (Silver King and No Cash), and two ‘control’ areas not known to be influenced by the tailings or adit discharges (Galena Hill and South McQuesten). Soil data from the Elsa tailings, Silver King and No Cash were assessed collectively, taking the site maximum to be the value of concern; however, data from samples taken directly from the Elsa tailings were not considered in the data set to select the COPC as tailings are not considered to be soil.

The background averages were calculated from measured data from the two control areas, Galena Hill and South McQuesten River. All values below the MDL were converted to ½ the MDL before the average values were calculated.

The CCME Soil Quality Guidelines for the Protection of Environmental and Human Health developed for residential/parkland use (CCME 2011) were used for comparison to the maximum measured concentrations. The use of the most restrictive residential/parkland criteria ensures that all potential COPC are captured in the screening process. The results are presented in Table A.3.

A large percentage (> 90%) of the measurements were below the method detection limit only for sodium. Sodium is also a part of the earth’s crust, and no guideline or toxicity data are available for sodium. Sodium was therefore not selected as a COPC. All other constituents had maximum measured concentrations that were greater than the background average and thus no constituents were dropped from the assessment on this basis. Of the remaining constituents, screening criteria were not available for calcium, iron, magnesium, manganese, phosphorus, potassium, strontium, titanium and zirconium. Of these, calcium, iron, magnesium, phosphorus, potassium and titanium were dropped from further assessment due to lack of human health and ecological toxicological data. Additionally, calcium, magnesium, phosphorus and potassium are considered as natural elements in the earth’s crust and are therefore not contaminants of concern. Aluminum is considered part of the earth’s crust and was dropped from further assessment.

Maximum concentrations of antimony, arsenic, barium, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium and zinc exceed CCME guidelines and were considered to be COPC. While no CCME guidelines exist for manganese, strontium and zirconium, toxicity data are available and these metals were therefore considered to be COPC. Toxicity data for zirconium are only available for terrestrial wildlife receptors and not humans and therefore zirconium will only be evaluated as a COPC for the terrestrial assessment.

A.1.2 Terrestrial Vegetation Screening

The screening process for terrestrial vegetation was similar to that described above. In the case of vegetation, the screening process was only used to identify COPC that may not have been selected in the soil screening process. If no phytotoxicity criteria were available, then these constituents were not considered further. Concentrations of metals in vegetation have been collected during four sampling programs, in 2007 through to 2010. Data are available for impacted areas (Silver King, No Cash, Husky Shaft, Elsa Tailings, Mackeno Tailings) and undisturbed 'control' areas (Galena Hill, South McQuesten). In addition, a minimal data set is available for vegetation in the Minto Bridge area, which has been identified as an area from where medicinal plants are traditionally harvested. Samples have included berries, browse, forage, inner bark, sap, fungi and lichen/moss. All available data from impacted areas were used in the screening process, collectively taking the site maximum to be the value of concern.

Similar to the soil screening process, background averages were calculated from the measured data from Galena Hill and South McQuesten River. All values below the MDL were converted to ½ the MDL before the average values were calculated.

A comparison was made to phytotoxicity values reported by McBride (19944), Langmuir *et al.* (2004) or Davis *et al.* (1978). The results of the vegetation screening are presented in Table A.4. Only those constituents for which criterion values are available are presented. Mercury and vanadium were removed from the assessment due to the large number of non-detects (i.e., >90%) in the data set. Molybdenum, barium and thallium had maximum measured concentrations below their respective phytotoxic levels. Aluminum is considered part of the earth's crust and was dropped from the assessment. Arsenic, cadmium, chromium, cobalt, lead, selenium and zinc were identified as COPC. All COPC with the exception of chromium were identified as soil COPC, therefore chromium was added to the COPC list.

Table A.1 Selection of Constituents of Potential Concern in Surface Water at the Historic Keno Hill Mine Site

Constituent	N	N<MDL	Bkgd Average	Maximum	CCME *	>90% below MDL?	< Bkgd Average?	COPC?	Rationale
Ammonia - N	44	28	0.02	0.11	4.0 (5)	N	N	N	Maximum > guideline value
Aluminum	662	56	0.29	15.3	0.1 (3)	N	N	N	Maximum > guideline; however, pH > 7 therefore aluminum in inaccessible form
Antimony	710	254	0.003	0.09	0.006 (2)	N	N	**Y**	Maximum > guideline value
Arsenic	780	92	0.011	0.18	0.005	N	N	**Y**	Maximum > guideline value
Barium	678	5	0.069	0.70	1 (2)	N	N	N	Maximum < guideline value
Beryllium	678	623	0.0001	0.072	-	Y	N	N	No guideline; however, heavily censored
Bismuth	643	621	0.002	0.29	-	Y	N	N	Heavily censored; no guideline or toxicity data
Boron	571	268	0.003	0.065	1.5	N	N	N	Maximum < guideline value
Cadmium	809	45	0.001	0.21	0.00011 (4)	N	N	**Y**	Maximum > guideline value
Calcium	671	1	49.3	823	-	N	N	N	No guideline or toxicity data; part of earth's crust
Chromium	678	348	0.001	163	0.05 (2)	N	N	**Y**	Maximum > guideline value
Cobalt	672	199	0.002	0.05	-	N	N	**Y**	No guideline; maximum > background
Copper	815	209	0.005	0.14	0.0079 (4)	N	N	**Y**	Maximum > guideline value
Iron	795	104	0.53	44.4	0.3	N	N	**Y**	Maximum > guideline value
Lead	839	78	0.02	1.2	0.019 (4)	N	N	**Y**	Maximum > guideline value
Lithium	647	61	0.006	0.19	-	N	N	N	No guideline or toxicity data; part of earth’s crust
Magnesium	671	1	13.8	184	-	N	N	N	No guideline or toxicity data; part of earth's crust
Manganese	786	32	0.14	121	0.05 (1)	N	N	**Y**	Maximum > guideline value
Mercury	29	21	0.0001	4.4	0.000026	N	N	**Y**	Maximum > guideline value
Molybdenum	669	543	0.001	0.11	0.073	N	N	**Y**	Maximum > guideline value
Nickel	784	60	0.010	0.3	0.280 (4)	N	N	**Y**	Maximum > guideline value
Phosphorus	191	106	0.044	1.4	-	N	N	N	No guideline or toxicity data; part of earth's crust
Potassium	652	241	0.50	5.9	-	N	N	N	No guideline or toxicity data; part of earth's crust
Selenium	672	191	0.004	0.5	0.001	N	N	**Y**	Maximum > guideline value
Silicon	672	7	2.85	20	-	N	N	N	No guideline or toxicity data
Silver	675	439	0.0002	3.5	0.0001	N	N	**Y**	Maximum > guideline value
Sodium	659	23	1.56	8.2	200 (1)	N	N	N	Maximum < guideline value
Strontium	666	0	0.18	1.8	-	N	N	**Y**	No guideline; maximum > background
Sulphur	618	1	24.6	791	-	N	N	N	No guideline or toxicity data
Tellurium	77	74	0.00005	124	-	Y	N	N	Heavily censored; no guideline or toxicity data
Thallium	501	457	0.0001	156	0.0008	Y	N	N	Maximum > guideline value; however, heavily censored
Thorium	182	143	0.001	0.027	-	N	N	N	No guideline or toxicity data
Tin	656	609	0.001	0.076	-	Y	N	N	No guideline; however, heavily censored
Titanium	660	81	0.01	20.7	-	N	N	N	No guideline or toxicity data
Uranium	636	150	0.01	0.19	0.015	N	N	**Y**	Maximum > guideline value

Table A.1 Selection of Constituents of Potential Concern in Surface Water at the Historic Keno Hill Mine Site (Cont'd)

Constituent	N	N<MDL	Bkgd Average	Maximum	CCME *	>90% below MDL?	< Bkgd Average?	COPC?	Rationale
Vanadium	665	142	0.001	0.04	-	N	N	**Y**	No guideline; maximum > background
Zinc	823	5	0.065	81.4	0.03	N	N	**Y**	Maximum > guideline value
Zirconium	628	559	0.001	3.05	-	N	N	N	No guideline or toxicity data; heavily censored (89% <MDL)

Notes: Values for metals are for total metals; all values are in mg/L
* CCME Water Quality Guidelines for the Protection of Aquatic Life, Long-Term Freshwater (CCME 2011) unless otherwise noted
(1) Health Canada drinking water guideline, aesthetic objective (Health Canada 2010)
(2) Health Canada drinking water guideline, maximum acceptable concentration (Health Canada 2010)
(3) For pH >= 6.5 (value of 0.005 of pH < 6.5; average pH from measured data in impacted water bodies is 7.7)
(4) Calculated from CCME equation based on average water hardness in impacted water bodies of 412 mg/L
(5) For pH of 7.5 and temperature of 5°C (closest to site averages of 7.67 and 3.96°C); converted from mg/L NH_3 to mg/L total ammonia by multiplying the guideline value of 4.84 by 0.8224

Table A.2 Selection of Constituents of Potential Concern in Sediment at the Historic Keno Hill Mine Site

Constituent	N	N<MDL	Bkgd Average	Maximum	Thompson *et al.* 2005 LEL	CCME ISQG	Guideline *	>90% below MDL?	< Bkgd Average?	COPC?	Rationale
Arsenic	112	0	43	14100	9.8	5.9	5.9	N	N	**Y**	Maximum value > guideline
Cadmium	117	0	2.5	4740	-	0.6	0.6	N	N	**Y**	Maximum value > guideline
Chromium	96	2	15	51.4	47.6	37.3	37.3	N	N	**Y**	Maximum value > guideline
Copper	117	0	27	504	22.2	35.7	35.7	N	N	**Y**	Maximum value > guideline
Lead	117	0	21	23900	36.7	35	35	N	N	**Y**	Maximum value > guideline
Mercury	44	1	0.06	3.94	-	0.17	0.17	N	N	**Y**	Maximum value > guideline
Molybdenum	96	23	1.2	7.0	13.8	-	13.8	N	N	N	Maximum value < guideline
Nickel	96	0	46	204	23.4	-	23.4	N	N	**Y**	Maximum value > guideline
Selenium	96	43	0.9	12.1	1.9	-	1.9	N	N	**Y**	Maximum value > guideline
Uranium	96	22	1.3	244	104.4	-	104.4	N	N	**Y**	Maximum value > guideline
Vanadium	89	0	24	43	35.2	-	35.2	N	N	**Y**	Maximum value > guideline
Zinc	96	0	293	195000	-	123	123	N	N	**Y**	Maximum value > guideline

Notes: Only those parameters for which guideline values are available are presented; values are in mg/kg on a dw basis (mg/kg dw)
* Guideline value is selected in order of preference as CCME Interim Sediment Quality Guideline (ISQG), Thompson *et al.* 2005 Lowest Effects Level (LEL).
- Guideline not available

Table A.3 Selection of Constituents of Potential Concern in Soil at the Historic Keno Hill Mine Site

Constituent	N	N<MDL	Bkgd Average	Maximum	Guideline *	>90% below MDL?	< Bkgd Average?	COPC?	Rationale
Aluminum	81	0	6377	14900	12	N	N	N	Maximum > guideline value but part of earth's crust
Antimony	81	4	4.10	430	20	N	N	**Y**	Maximum > guideline value
Arsenic	81	0	45.5	3490	12	N	N	**Y**	Maximum > guideline value
Barium	81	0	217	3580	500	N	N	**Y**	Maximum > guideline value
Beryllium	81	39	0.45	0.80	4	N	N	N	Maximum < guideline value
Boron	32	0	2.85	9.0	120 (1)	N	N	N	Maximum < guideline value
Cadmium	81	2	3.73	248	10	N	N	**Y**	Maximum > guideline value
Calcium	81	0	10045	47800	-	N	N	N	No guideline or toxicity data; part of earth's crust
Chromium	81	0	12.2	27.0	64	N	N	N	Maximum < guideline value
Cobalt	81	0	10.75	176	50	N	N	**Y**	Maximum > guideline value
Copper	81	0	26.6	224	63	N	N	**Y**	Maximum > guideline value
Iron	81	0	18688	162000	-	N	N	N	No guideline or toxicity data
Lead	81	0	91.3	26800	140	N	N	**Y**	Maximum > guideline value
Magnesium	81	0	2960	14700	-	N	N	N	No guideline or toxicity data; part of earth's crust
Manganese	81	0	1190	96000	-	N	N	**Y**	No guideline; maximum > background
Mercury	81	7	0.051	1.92	6.6	N	N	N	Maximum < guideline value
Molybdenum	81	0	1.02	15.0	10	N	N	**Y**	Maximum > guideline value
Nickel	81	0	35.1	89.8	50	N	N	**Y**	Maximum > guideline value
Phosphorus	81	0	729	1540	-	N	N	N	No guideline or toxicity data; part of earth's crust
Potassium	81	0	290	881	-	N	N	N	No guideline or toxicity data; part of earth's crust
Selenium	81	9	1.01	7.00	1	N	N	**Y**	Maximum > guideline value
Silver	81	1	1.82	130	20	N	N	**Y**	Maximum > guideline value
Sodium	81	75	23.9	69.0	-	Y	N	N	Heavily censored; no guideline or toxicity data and part of earth's crust
Strontium	81	0	35.7	153	-	N	N	**Y**	No guideline; maximum > background
Thallium	81	40	0.06	5.30	1	N	N	**Y**	Maximum > guideline value
Tin	81	43	2.3	15.0	50	N	N	N	Maximum < guideline value
Titanium	81	0	91.5	322	-	N	N	N	No guideline or toxicity data
Vanadium	81	0	18.2	43.0	130	N	N	N	Maximum < guideline value
Zinc	81	0	352.9	14800	200	N	N	**Y**	Maximum > guideline value
Zirconium	81	12	1.45	18.7	-	N	N	**Y**	No guideline; maximum > background

Notes: All values in mg/kg on a dw basis (mg/kg dw)

* CCME Soil Quality Guidelines for the Protection of Environmental and Human Health, Residential/Parkland use (CCME 2011)

1 No value available from the CCME; value obtained from the MOE (2009) for coarse-grained soil and residential/parkland land use

No data available for bismuth, lithium, silicon, sulphur, tellurium, uranium, or thorium

Table A.4 Selection of Constituents of Potential Concern in Terrestrial Vegetation at the Historic Keno Hill Mine Site

Parameter	N	N<MDL	Bkgd Average	Maximum	Phytotoxic Level	>90% below MDL?	<1.1 x Bkgd Average?	COPC?	Rationale
Aluminum	226	0	6.4	210	50 (1)	N	N	N	Maximum > guideline value but part of earth's crust
Antimony	227	165	0.05	3.1	150 (1)	N	N	N	Maximum < guideline value
Arsenic	227	44	0.05	17	3 (2)	N	N	**Y**	Maximum > guideline value
Barium	227	0	45.3	200	400 (3)	N	N	N	Maximum < guideline value
Cadmium	227	25	0.6	43	5 (1, 2)	N	N	**Y**	Maximum > guideline value
Chromium	227	140	0.1	8	5 (1, 3)	N	N	**Y**	Maximum > guideline value
Cobalt	227	178	0.17	8.1	3 (3)	N	N	**Y**	Maximum > guideline value
Lead	227	17	0.08	125	20 (3)	N	N	**Y**	Maximum > guideline value
Mercury	227	218	0.01	0.05	1 (1)	Y	N	N	Heavily censored
Molybdenum	227	155	0.09	4.7	10 (1)	N	N	N	Maximum < guideline value
Selenium	226	134	0.11	5.6	5 (1)	N	N	**Y**	Maximum > guideline value
Thallium	227	175	0.01	8.72	11 (3)	N	N	N	Maximum < guideline value
Vanadium	227	223	0.27	1.0	5 (1)	Y	N	N	Heavily censored
Zinc	227	0	59.8	1370	100 (1)	N	N	**Y**	Maximum > guideline value

Notes: All values in mg/kg on a dw basis (mg/kg dw)
(1) Leaf tissue concentration in plants that are neither sensitive or tolerant (McBride 1994)
(2) Phytotoxic concentration in plant foliage (Langmuir *et al.* 2004)
(3) Upper critical level in leaves and shoots of spring barley associated with reduced yield (Davis *et al.* 1978)

A.2 OVERALL LIST OF COPC CONSIDERED

A summary table with the selected COPC for surface water and sediment is provided in Table A.5 for the aquatic environment assessment.

A summary table with the selected COPC for soil and terrestrial vegetation is provided in Table A.6 for the terrestrial environment.

Table A.5 Summary of COPC for the Historic Keno Hill Mine Site - Aquatic Environment Assessment

Parameter	Surface Water	Sediment	List of COPC
Ammonia - N			
Aluminum			
Antimony	Y		Antimony (1)
Arsenic	Y	Y	Arsenic
Barium			
Beryllium			
Bismuth			
Boron			
Cadmium	Y	Y	Cadmium
Calcium			
Chromium	Y	Y	Chromium
Cobalt	Y		Cobalt (1)
Copper	Y	Y	Copper
Iron	Y		Iron (1)
Lead	Y	Y	Lead
Lithium			
Magnesium			
Manganese	Y		Manganese (1)
Mercury	Y	Y	Mercury
Molybdenum	Y		Molybdenum
Nickel	Y	Y	Nickel
Phosphorus			
Potassium			
Selenium	Y	Y	Selenium
Silicon			
Silver	Y		Silver (1)
Sodium			
Strontium	Y		Strontium (1)
Sulphur			
Tellurium			
Thallium			
Thorium			
Tin			
Titanium			
Uranium	Y	Y	Uranium
Vanadium	Y	Y	Vanadium
Zinc	Y	Y	Zinc
Zirconium			

Notes:
1 No sediment toxicity data available

Table A.6 Summary of COPC for the Historic Keno Hill Mine Site - Terrestrial Environment Assessment

Parameter	Soil	Terrestrial Vegetation	List of COPC
Aluminum			
Antimony	Y		Antimony
Arsenic	Y	Y	Arsenic
Barium	Y		Barium
Beryllium			
Bismuth			
Boron			
Cadmium	Y	Y	Cadmium
Calcium			
Chromium		Y	Chromium
Cobalt	Y	Y	Cobalt
Copper	Y		Copper
Iron			
Lead	Y	Y	Lead
Lithium			
Magnesium			
Manganese	Y		Manganese
Mercury			Mercury
Molybdenum	Y		Molybdenum
Nickel	Y		Nickel
Phosphorus			
Potassium			
Selenium	Y	Y	Selenium
Silicon			
Silver	Y		Silver
Sodium			
Strontium	Y		Strontium
Sulphur			
Tellurium			
Thallium	Y		Thallium
Thorium			
Tin			
Titanium			
Uranium			Uranium
Vanadium			Vanadium
Zinc	Y	Y	Zinc
Zirconium	Y		Zirconium (1)

Notes:

1 Evaluated for terrestrial receptors only

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APPENDIX B

DETAILED HUMAN AND ECOLOGICAL RECEPTORS RESULTS

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APPENDIX B: DETAILED HUMAN AND ECOLOGICAL RECEPTORS RESULTS

This appendix provides detailed intakes estimated for human and ecological receptors at the historic Keno Hill Mine site for each exposure pathway.

B.1 HUMAN RECEPTOR RESULTS

Table B.1 Calculated Intakes (Non-carcinogenic) for Toddler at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	1.34E-05	3.92E-06	1.19E-06	5.00E-07	6.31E-05	2.55E-05	4.66E-06	1.42E-07	1.00E-06	5.50E-07	-	3.46E-07	1.80E-06
Arsenic	4.00E-05	6.11E-05	1.03E-05	4.16E-06	1.50E-05	2.04E-04	4.13E-05	1.21E-06	1.06E-05	3.21E-05	-	3.46E-07	9.69E-06
Barium	3.72E-04	1.33E-04	1.06E-05	1.06E-05	9.43E-05	1.04E-04	5.09E-06	2.19E-06	1.41E-06	4.57E-07	-	7.13E-05	2.08E-05
Cadmium	3.59E-06	1.04E-04	8.39E-07	1.58E-07	1.16E-05	6.21E-05	1.24E-06	4.59E-08	5.35E-06	3.32E-06	-	2.84E-06	1.41E-06
Chromium	4.09E-06	5.23E-05	5.69E-06	2.88E-06	2.52E-05	7.81E-05	7.36E-06	7.44E-07	1.75E-06	1.46E-07		1.38E-06	1.54E-06
Cobalt	8.73E-06	2.88E-05	8.22E-07	2.82E-07	1.30E-05	9.54E-06	4.97E-07	8.13E-08	3.71E-06	8.20E-07	-	3.46E-07	2.94E-06
Copper	2.37E-05	1.64E-04	4.06E-05	3.11E-05	8.91E-04	1.08E-03	6.13E-05	6.87E-06	3.21E-06	1.07E-06	-	3.49E-05	3.38E-06
Lead	4.29E-04	2.21E-04	1.15E-05	4.67E-06	1.57E-04	5.41E-04	1.64E-04	1.36E-06	6.73E-06	8.35E-06	-	3.46E-07	3.07E-05
Manganese	2.05E-03	3.53E-03	3.18E-04	2.00E-04	3.14E-03	3.99E-03	3.88E-04	4.32E-05	1.41E-06	7.22E-07	-	9.55E-04	2.45E-04
Mercury	9.09E-08	3.99E-05	7.47E-08	4.82E-08	2.46E-06	3.85E-06	2.35E-07	1.08E-08	3.02E-10	2.14E-10	-	3.46E-08	5.41E-09
Molybdenum	3.14E-06	1.04E-04	2.06E-07	7.94E-08	8.26E-06	9.51E-06	1.70E-07	1.81E-08	6.55E-08	3.20E-08	-	2.54E-06	1.04E-07
Nickel	4.86E-05	5.52E-04	3.53E-05	1.34E-05	1.36E-04	3.31E-04	1.55E-05	3.75E-06	4.35E-06	4.13E-07	-	1.02E-05	1.10E-05
Selenium	2.11E-06	1.44E-04	2.22E-05	1.06E-05	2.16E-04	5.91E-04	1.59E-05	2.44E-06	3.52E-06	4.92E-06	-	6.92E-07	1.55E-07
Silver	5.41E-06	4.58E-06	7.96E-07	3.23E-07	1.21E-05	3.43E-05	4.73E-06	9.38E-08	3.10E-07	2.24E-07	-	3.46E-08	7.08E-07
Strontium	9.36E-04	1.15E-03	1.98E-05	7.01E-06	8.15E-04	9.31E-04	9.75E-06	1.53E-06	5.55E-07	2.09E-06	-	8.52E-06	4.09E-06
Thallium	1.50E-07	6.21E-06	7.77E-07	9.18E-07	4.59E-06	1.38E-05	2.22E-06	1.89E-07	3.14E-07	1.86E-06	-	6.92E-08	6.57E-09
Uranium	4.95E-06	3.27E-07	7.69E-09	6.12E-09	1.19E-06	8.81E-06	9.65E-09	1.25E-09	1.69E-08	6.87E-07	-	1.38E-07	N/A
Vanadium	3.45E-06	1.63E-05	3.59E-06	1.66E-06	5.71E-05	8.65E-05	3.68E-06	4.46E-07	3.58E-06	2.95E-06	-	1.73E-06	2.29E-06
Zinc	4.03E-04	1.69E-02	2.33E-02	7.77E-03	2.33E-01	1.58E+00	2.85E-02	1.89E-03	1.20E-04	1.15E-04	-	1.45E-04	1.05E-04

Note: N/A – not assessed due to lack of data
"-" – pathway not assessed for this receptor

Table B.1 (Cont'd) Calculated Intakes (Non-carcinogenic) for Toddler at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Total Ingestion	Total Dermal	Inhalation
	(mg/(kg-d))	(mg/(kg-d))	(mg/m^3)
Antimony	1.16E-04	9.50E-07	1.73E-09
Arsenic	4.30E-04	1.54E-06	9.35E-09
Barium	8.25E-04	1.10E-05	2.01E-08
Cadmium	1.96E-04	7.44E-08	1.36E-09
Chromium	1.81E-04	8.15E-07	1.48E-09
Cobalt	6.96E-05	1.56E-06	2.84E-09
Copper	2.34E-03	1.07E-06	3.26E-09
Lead	1.58E-03	9.76E-07	2.96E-08
Manganese	1.49E-02	1.30E-04	2.36E-07
Mercury	4.67E-05	2.86E-09	5.22E-12
Molybdenum	1.28E-04	5.51E-09	1.01E-10
Nickel	1.16E-03	4.95E-06	1.06E-08
Selenium	1.01E-03	8.18E-09	1.49E-10
Silver	6.36E-05	9.37E-07	6.83E-10
Strontium	3.89E-03	2.16E-06	3.95E-09
Thallium	3.11E-05	3.48E-10	6.34E-12
Uranium	1.61E-05	N/A	N/A
Vanadium	1.83E-04	1.21E-06	2.21E-09
Zinc	1.90E+00	5.55E-05	1.01E-07

Note: N/A – not assessed due to lack of data

Table B.2 Calculated Intakes (Non-carcinogenic) for Child at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	8.94E-06	3.19E-06	8.51E-07	3.57E-07	4.50E-05	1.82E-05	3.33E-06	1.02E-07	7.14E-07	3.93E-07	-	1.97E-07	8.31E-07
Arsenic	2.68E-05	4.97E-05	7.36E-06	2.97E-06	1.07E-05	1.45E-04	2.95E-05	8.66E-07	7.55E-06	2.29E-05	-	1.97E-07	4.49E-06
Barium	2.49E-04	1.08E-04	7.60E-06	7.55E-06	6.73E-05	7.40E-05	3.63E-06	1.56E-06	1.01E-06	3.26E-07	-	4.06E-05	9.62E-06
Cadmium	2.40E-06	8.44E-05	5.99E-07	1.13E-07	8.25E-06	4.43E-05	8.84E-07	3.27E-08	3.82E-06	2.37E-06	-	1.62E-06	6.51E-07
Chromium	2.74E-06	4.25E-05	4.06E-06	2.05E-06	1.80E-05	5.58E-05	5.25E-06	5.31E-07	1.25E-06	1.04E-07		7.88E-07	7.13E-07
Cobalt	5.84E-06	2.34E-05	5.87E-07	2.01E-07	9.30E-06	6.81E-06	3.55E-07	5.80E-08	2.65E-06	5.85E-07	-	1.97E-07	1.36E-06
Copper	1.58E-05	1.33E-04	2.90E-05	2.22E-05	6.36E-04	7.72E-04	4.38E-05	4.90E-06	2.29E-06	7.62E-07	-	1.99E-05	1.57E-06
Lead	2.87E-04	1.79E-04	8.22E-06	3.33E-06	1.12E-04	3.86E-04	1.17E-04	9.70E-07	4.80E-06	5.96E-06	-	1.97E-07	1.42E-05
Manganese	1.37E-03	2.87E-03	2.27E-04	1.43E-04	2.24E-03	2.84E-03	2.77E-04	3.08E-05	1.00E-06	5.15E-07	-	5.44E-04	1.13E-04
Mercury	6.08E-08	3.24E-05	5.33E-08	3.44E-08	1.75E-06	2.75E-06	1.68E-07	7.70E-09	2.16E-10	1.53E-10	-	1.97E-08	2.50E-09
Molybdenum	2.10E-06	8.47E-05	1.47E-07	5.66E-08	5.90E-06	6.78E-06	1.21E-07	1.29E-08	4.67E-08	2.28E-08	-	1.45E-06	4.82E-08
Nickel	3.25E-05	4.49E-04	2.52E-05	9.53E-06	9.69E-05	2.36E-04	1.11E-05	2.68E-06	3.11E-06	2.95E-07	-	5.79E-06	5.09E-06
Selenium	1.41E-06	1.17E-04	1.58E-05	7.57E-06	1.54E-04	4.22E-04	1.14E-05	1.74E-06	2.51E-06	3.51E-06	-	3.94E-07	7.15E-08
Silver	3.62E-06	3.72E-06	5.68E-07	2.30E-07	8.64E-06	2.45E-05	3.38E-06	6.69E-08	2.21E-07	1.60E-07	-	1.97E-08	3.28E-07
Strontium	6.26E-04	9.35E-04	1.41E-05	5.00E-06	5.82E-04	6.65E-04	6.96E-06	1.09E-06	3.96E-07	1.49E-06	-	4.85E-06	1.89E-06
Thallium	1.00E-07	5.05E-06	5.55E-07	6.55E-07	3.27E-06	9.38E-06	1.59E-06	1.35E-07	2.24E-07	1.33E-06	-	3.94E-08	3.04E-09
Uranium	3.31E-06	2.66E-07	5.49E-09	4.37E-09	8.48E-07	6.29E-06	6.88E-09	8.96E-10	1.20E-08	4.90E-07	-	7.88E-08	N/A
Vanadium	2.31E-06	1.33E-05	2.57E-06	1.19E-06	4.07E-05	6.18E-05	2.63E-06	3.18E-07	2.55E-06	2.10E-06	-	9.86E-07	1.06E-06
Zinc	2.70E-04	1.38E-02	1.66E-02	5.55E-03	1.66E-01	1.13E+00	2.03E-02	1.35E-03	8.57E-05	8.19E-05	-	8.24E-05	4.86E-05

Note: N/A – not assessed due to lack of data
"-" – pathway not assessed for this receptor

Table B.2 (Cont'd) Calculated Intakes (Non-carcinogenic) for Child at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Total Ingestion	Total Dermal	Inhalation
	(mg/(kg-d))	(mg/(kg-d))	(mg/m^3)
Antimony	8.21E-05	7.24E-07	1.73E-09
Arsenic	3.08E-04	1.17E-06	9.35E-09
Barium	5.70E-04	8.38E-06	2.01E-08
Cadmium	1.50E-04	5.67E-08	1.36E-09
Chromium	1.34E-04	6.21E-07	1.48E-09
Cobalt	5.13E-05	1.19E-06	2.84E-09
Copper	1.68E-03	8.18E-07	3.26E-09
Lead	1.12E-03	7.43E-07	2.96E-08
Manganese	1.07E-02	9.87E-05	2.36E-07
Mercury	3.72E-05	2.18E-09	5.22E-12
Molybdenum	1.01E-04	4.20E-09	1.01E-10
Nickel	8.77E-04	3.77E-06	1.06E-08
Selenium	7.38E-04	6.23E-09	1.49E-10
Silver	4.54E-05	7.14E-07	6.83E-10
Strontium	2.84E-03	1.65E-06	3.95E-09
Thallium	2.28E-05	2.65E-10	6.34E-12
Uranium	1.13E-05	N/A	N/A
Vanadium	1.31E-04	9.25E-07	2.21E-09
Zinc	1.35E+00	4.23E-05	1.01E-07

Note: N/A – not assessed due to lack of data

Table B.3 Calculated Intakes (Non-carcinogenic) for Teen at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	6.16E-06	2.17E-06	6.34E-07	2.66E-07	3.35E-05	1.35E-05	2.48E-06	7.57E-08	5.32E-07	2.93E-07	8.68E-08	9.97E-08	5.73E-08
Arsenic	1.84E-05	3.38E-05	5.48E-06	2.21E-06	8.00E-06	1.08E-04	2.20E-05	6.45E-07	5.62E-06	1.70E-05	8.68E-08	9.97E-08	3.09E-07
Barium	1.71E-04	7.33E-05	5.66E-06	5.62E-06	5.01E-05	5.51E-05	2.70E-06	1.16E-06	7.49E-07	2.43E-07	1.68E-04	2.05E-05	6.63E-07
Cadmium	1.65E-06	5.74E-05	4.46E-07	8.38E-08	6.15E-06	3.30E-05	6.59E-07	2.44E-08	2.85E-06	1.76E-06	1.73E-08	8.17E-07	4.48E-08
Chromium	1.89E-06	2.89E-05	3.02E-06	1.53E-06	1.34E-05	4.15E-05	3.91E-06	3.95E-07	9.31E-07	7.74E-08	4.71E-07	3.99E-07	4.91E-08
Cobalt	4.02E-06	1.59E-05	4.37E-07	1.50E-07	6.93E-06	5.07E-06	2.64E-07	4.32E-08	1.97E-06	4.36E-07	8.68E-08	9.97E-08	9.38E-08
Copper	1.09E-05	9.05E-05	2.16E-05	1.66E-05	4.74E-04	5.75E-04	3.26E-05	3.65E-06	1.71E-06	5.67E-07	6.49E-06	1.01E-05	1.08E-07
Lead	1.97E-04	1.22E-04	6.12E-06	2.48E-06	8.34E-05	2.88E-04	8.73E-05	7.22E-07	3.58E-06	4.44E-06	3.01E-07	9.97E-08	9.80E-07
Manganese	9.46E-04	1.95E-03	1.69E-04	1.06E-04	1.67E-03	2.12E-03	2.06E-04	2.29E-05	7.48E-07	3.84E-07	6.65E-04	2.75E-04	7.81E-06
Mercury	4.19E-08	2.20E-05	3.97E-08	2.56E-08	1.31E-06	2.05E-06	1.25E-07	5.73E-09	1.61E-10	1.14E-10	8.68E-09	9.97E-09	1.72E-10
Molybdenum	1.45E-06	5.76E-05	1.10E-07	4.22E-08	4.39E-06	5.05E-06	9.01E-08	9.59E-09	3.48E-08	1.70E-08	1.34E-07	7.32E-07	3.32E-09
Nickel	2.24E-05	3.05E-04	1.88E-05	7.10E-06	7.22E-05	1.76E-04	8.24E-06	1.99E-06	2.31E-06	2.20E-07	8.26E-07	2.93E-06	3.51E-07
Selenium	9.71E-07	7.95E-05	1.18E-05	5.64E-06	1.15E-04	3.14E-04	8.47E-06	1.30E-06	1.87E-06	2.61E-06	1.73E-07	1.99E-07	4.93E-09
Silver	2.49E-06	2.53E-06	4.23E-07	1.71E-07	6.44E-06	1.82E-05	2.52E-06	4.98E-08	1.65E-07	1.19E-07	8.68E-09	9.97E-09	2.26E-08
Strontium	4.31E-04	6.36E-04	1.05E-05	3.72E-06	4.33E-04	4.95E-04	5.18E-06	8.13E-07	2.95E-07	1.11E-06	1.02E-05	2.45E-06	1.30E-07
Thallium	6.90E-08	3.43E-06	4.13E-07	4.88E-07	2.44E-06	7.32E-06	1.18E-06	1.01E-07	1.67E-07	9.90E-07	6.91E-08	1.99E-08	2.09E-10
Uranium	2.28E-06	1.81E-07	4.09E-09	3.25E-09	6.31E-07	4.68E-06	5.13E-09	6.67E-10	8.96E-09	3.65E-07	3.46E-08	3.99E-08	N/A
Vanadium	1.59E-06	9.03E-06	1.91E-06	8.85E-07	3.03E-05	4.60E-05	1.96E-06	2.37E-07	1.90E-06	1.57E-06	4.33E-07	4.98E-07	7.32E-08
Zinc	1.86E-04	9.36E-03	1.24E-02	4.13E-03	1.24E-01	8.42E-01	1.52E-02	1.01E-03	6.38E-05	6.10E-05	6.26E-05	4.17E-05	3.34E-06

Note: N/A – not assessed due to lack of data

Table B.3 (Cont'd) Calculated Intakes (Non-carcinogenic) for Teen at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Total Ingestion	Total Dermal	Inhalation
	(mg/(kg-d))	(mg/(kg-d))	(mg/m^3)
Antimony	5.99E-05	5.80E-07	1.73E-09
Arsenic	2.22E-04	9.40E-07	9.35E-09
Barium	5.56E-04	6.72E-06	2.01E-08
Cadmium	1.05E-04	4.54E-08	1.36E-09
Chromium	9.65E-05	4.97E-07	1.48E-09
Cobalt	3.55E-05	9.51E-07	2.84E-09
Copper	1.24E-03	6.56E-07	3.26E-09
Lead	7.97E-04	5.96E-07	2.96E-08
Manganese	8.14E-03	7.91E-05	2.36E-07
Mercury	2.57E-05	1.75E-09	5.22E-12
Molybdenum	6.97E-05	3.37E-09	1.01E-10
Nickel	6.19E-04	3.02E-06	1.06E-08
Selenium	5.42E-04	4.99E-09	1.49E-10
Silver	3.32E-05	5.72E-07	6.83E-10
Strontium	2.03E-03	1.32E-06	3.95E-09
Thallium	1.67E-05	2.12E-10	6.34E-12
Uranium	8.24E-06	N/A	N/A
Vanadium	9.64E-05	7.42E-07	2.21E-09
Zinc	1.01E+00	3.39E-05	1.01E-07

Note: N/A – not assessed due to lack of data

Table B.4 Calculated Intakes (Non-carcinogenic) for Adult at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	7.80E-06	1.83E-06	5.35E-07	2.24E-07	2.83E-05	1.14E-05	2.09E-06	6.39E-08	4.49E-07	2.47E-07	7.33E-08	8.42E-08	5.48E-08
Arsenic	2.34E-05	2.85E-05	4.63E-06	1.87E-06	6.75E-06	9.14E-05	1.85E-05	5.45E-07	4.75E-06	1.44E-05	7.33E-08	8.42E-08	2.96E-07
Barium	2.17E-04	6.19E-05	4.78E-06	4.75E-06	4.23E-05	4.65E-05	2.28E-06	9.83E-07	6.32E-07	2.05E-07	1.42E-04	1.73E-05	6.34E-07
Cadmium	2.09E-06	4.85E-05	3.77E-07	7.08E-08	5.19E-06	2.79E-05	5.56E-07	2.06E-08	2.40E-06	1.49E-06	1.46E-08	6.90E-07	4.29E-08
Chromium	2.39E-06	2.44E-05	2.55E-06	1.29E-06	1.13E-05	3.51E-05	3.30E-06	3.34E-07	7.86E-07	6.54E-08	3.98E-07	3.37E-07	4.70E-08
Cobalt	5.09E-06	1.34E-05	3.69E-07	1.27E-07	5.85E-06	4.28E-06	2.23E-07	3.65E-08	1.66E-06	3.68E-07	7.33E-08	8.42E-08	8.98E-08
Copper	1.38E-05	7.64E-05	1.82E-05	1.40E-05	4.00E-04	4.86E-04	2.75E-05	3.08E-06	1.44E-06	4.79E-07	5.48E-06	8.50E-06	1.03E-07
Lead	2.50E-04	1.03E-04	5.17E-06	2.10E-06	7.04E-05	2.43E-04	7.37E-05	6.10E-07	3.02E-06	3.75E-06	2.55E-07	8.42E-08	9.38E-07
Manganese	1.20E-03	1.65E-03	1.43E-04	8.97E-05	1.41E-03	1.79E-03	1.74E-04	1.94E-05	6.31E-07	3.24E-07	5.61E-04	2.32E-04	7.47E-06
Mercury	5.30E-08	1.86E-05	3.35E-08	2.17E-08	1.10E-06	1.73E-06	1.06E-07	4.84E-09	1.36E-10	9.60E-11	7.33E-09	8.42E-09	1.65E-10
Molybdenum	1.83E-06	4.87E-05	9.25E-08	3.56E-08	3.71E-06	4.27E-06	7.61E-08	8.10E-09	2.94E-08	1.43E-08	1.13E-07	6.18E-07	3.18E-09
Nickel	2.84E-05	2.58E-04	1.59E-05	5.99E-06	6.09E-05	1.49E-04	6.96E-06	1.68E-06	1.95E-06	1.86E-07	6.97E-07	2.47E-06	3.36E-07
Selenium	1.23E-06	6.71E-05	9.97E-06	4.76E-06	9.70E-05	2.65E-04	7.15E-06	1.10E-06	1.58E-06	2.21E-06	1.46E-07	1.68E-07	4.72E-09
Silver	3.16E-06	2.14E-06	3.57E-07	1.45E-07	5.44E-06	1.54E-05	2.12E-06	4.21E-08	1.39E-07	1.00E-07	7.33E-09	8.42E-09	2.16E-08
Strontium	5.46E-04	5.37E-04	8.89E-06	3.14E-06	3.66E-04	4.18E-04	4.38E-06	6.86E-07	2.49E-07	9.40E-07	8.65E-06	2.07E-06	1.25E-07
Thallium	8.74E-08	2.90E-06	3.49E-07	4.12E-07	2.06E-06	2.07E-06	9.97E-07	8.49E-08	1.41E-07	8.36E-07	5.83E-08	1.68E-08	2.00E-10
Uranium	2.89E-06	1.53E-07	3.45E-09	2.75E-09	5.33E-07	6.18E-06	4.33E-09	5.63E-10	7.56E-09	3.08E-07	2.92E-08	3.37E-08	N/A
Vanadium	2.01E-06	7.63E-06	1.61E-06	7.47E-07	2.56E-05	3.88E-05	1.65E-06	2.00E-07	1.61E-06	1.32E-06	3.66E-07	4.21E-07	7.00E-08
Zinc	2.35E-04	7.90E-03	1.05E-02	3.49E-03	1.04E-01	7.11E-01	1.28E-02	8.49E-04	5.39E-05	5.15E-05	5.29E-05	3.52E-05	3.20E-06

Note: N/A – not assessed due to lack of data

Table B.4 (Cont'd) Calculated Intakes (Non-carcinogenic) for Adult at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Total Ingestion	Total Dermal	Inhalation
	(mg/(kg-d))	(mg/(kg-d))	(mg/m^3)
Antimony	5.32E-05	5.52E-07	1.73E-09
Arsenic	1.95E-04	8.94E-07	9.35E-09
Barium	5.42E-04	6.39E-06	2.01E-08
Cadmium	8.93E-05	4.32E-08	1.36E-09
Chromium	8.23E-05	4.73E-07	1.48E-09
Cobalt	3.17E-05	9.04E-07	2.84E-09
Copper	1.05E-03	6.24E-07	3.26E-09
Lead	7.56E-04	5.67E-07	2.96E-08
Manganese	7.27E-03	7.52E-05	2.36E-07
Mercury	2.17E-05	1.66E-09	5.22E-12
Molybdenum	5.95E-05	3.20E-09	1.01E-10
Nickel	5.32E-04	2.87E-06	1.06E-08
Selenium	4.58E-04	4.75E-09	1.49E-10
Silver	2.90E-05	5.44E-07	6.83E-10
Strontium	1.90E-03	1.26E-06	3.95E-09
Thallium	1.41E-05	2.02E-10	6.34E-12
Uranium	7.92E-06	N/A	N/A
Vanadium	8.21E-05	7.05E-07	2.21E-09
Zinc	8.51E-01	3.22E-05	1.01E-07

Note: N/A – not assessed due to lack of data

Table B.5 Calculated Intakes (Carcinogenic) for Adult at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	5.95E-06	1.40E-06	4.08E-07	1.71E-07	2.16E-05	8.71E-06	1.59E-06	4.87E-08	3.43E-07	1.88E-07	5.59E-08	6.42E-08	4.18E-08
Arsenic	1.78E-05	2.18E-05	3.53E-06	1.42E-06	5.15E-06	6.97E-05	1.41E-05	4.15E-07	3.62E-06	1.10E-05	5.59E-08	6.42E-08	2.26E-07
Barium	1.66E-04	4.72E-05	3.64E-06	3.62E-06	3.23E-05	3.55E-05	1.74E-06	7.50E-07	4.82E-07	1.56E-07	1.08E-04	1.32E-05	4.84E-07
Cadmium	1.60E-06	3.70E-05	2.87E-07	5.40E-08	3.96E-06	2.13E-05	4.24E-07	1.57E-08	1.83E-06	1.14E-06	1.11E-08	5.26E-07	3.27E-08
Chromium	1.82E-06	1.86E-05	1.95E-06	9.85E-07	8.64E-06	2.67E-05	2.52E-06	2.55E-07	5.99E-07	4.98E-08	3.03E-07	2.57E-07	3.58E-08
Cobalt	3.88E-06	1.02E-05	2.81E-07	9.66E-08	4.46E-06	3.27E-06	1.70E-07	2.78E-08	1.27E-06	2.81E-07	5.59E-08	6.42E-08	6.85E-08
Copper	1.05E-05	5.83E-05	1.39E-05	1.07E-05	3.05E-04	3.70E-04	2.10E-05	2.35E-06	1.10E-06	3.65E-07	4.18E-06	6.48E-06	7.87E-08
Lead	1.91E-04	7.86E-05	3.94E-06	1.60E-06	5.37E-05	1.85E-04	5.62E-05	4.65E-07	2.30E-06	2.86E-06	1.94E-07	6.42E-08	7.15E-07
Manganese	9.14E-04	1.26E-03	1.09E-04	6.84E-05	1.07E-03	1.36E-03	1.33E-04	1.48E-05	4.81E-07	2.47E-07	4.28E-04	1.77E-04	5.70E-06
Mercury	4.04E-08	1.42E-05	2.56E-08	1.65E-08	8.41E-07	1.32E-06	8.05E-08	3.69E-09	1.03E-10	7.32E-11	5.59E-09	6.42E-09	1.26E-10
Molybdenum	1.40E-06	3.71E-05	7.05E-08	2.72E-08	2.83E-06	3.25E-06	5.80E-08	6.18E-09	2.24E-08	1.09E-08	8.65E-08	4.71E-07	2.42E-09
Nickel	2.16E-05	1.97E-04	1.21E-05	4.57E-06	4.65E-05	1.13E-04	5.31E-06	1.28E-06	1.49E-06	1.41E-07	5.32E-07	1.88E-06	2.56E-07
Selenium	9.38E-07	5.12E-05	7.60E-06	3.63E-06	7.40E-05	2.02E-04	5.45E-06	8.35E-07	1.20E-06	1.68E-06	1.11E-07	1.28E-07	3.60E-09
Silver	2.41E-06	1.63E-06	2.72E-07	1.10E-07	4.14E-06	1.17E-05	1.62E-06	3.21E-08	1.06E-07	7.66E-08	5.59E-09	6.42E-09	1.65E-08
Strontium	4.17E-04	4.09E-04	6.78E-06	2.40E-06	2.79E-04	3.19E-04	3.34E-06	5.23E-07	1.90E-07	7.17E-07	6.60E-06	1.58E-06	9.52E-08
Thallium	6.66E-08	2.21E-06	2.66E-07	3.14E-07	1.57E-06	4.71E-06	7.60E-07	6.47E-08	1.08E-07	6.37E-07	4.45E-08	1.28E-08	1.53E-10
Uranium	2.20E-06	1.16E-07	2.63E-09	2.09E-09	4.07E-07	3.01E-06	3.30E-09	4.29E-10	5.77E-09	2.35E-07	2.23E-08	2.57E-08	N/A
Vanadium	1.54E-06	5.82E-06	1.23E-06	5.70E-07	1.95E-05	2.96E-05	1.26E-06	1.53E-07	1.23E-06	1.01E-06	2.79E-07	3.21E-07	5.34E-08
Zinc	1.79E-04	6.03E-03	7.97E-03	2.66E-03	7.97E-02	5.42E-01	9.76E-03	6.47E-04	4.11E-05	3.93E-05	4.03E-05	2.68E-05	2.44E-06

Note: N/A – not assessed due to lack of data

Table B.5 (Cont'd) Calculated Intakes (Carcinogenic) for Adult at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Total Ingestion	Total Dermal	Inhalation
	(mg/(kg-d))	(mg/(kg-d))	(mg/m^3)
Antimony	4.06E-05	4.21E-07	1.32E-09
Arsenic	1.49E-04	6.82E-07	7.13E-09
Barium	4.13E-04	4.87E-06	1.53E-08
Cadmium	6.81E-05	3.29E-08	1.03E-09
Chromium	6.28E-05	3.61E-07	1.13E-09
Cobalt	2.42E-05	6.89E-07	2.16E-09
Copper	8.04E-04	4.76E-07	2.49E-09
Lead	5.77E-04	4.32E-07	2.26E-08
Manganese	5.54E-03	5.74E-05	1.80E-07
Mercury	1.65E-05	1.27E-09	3.98E-12
Molybdenum	4.53E-05	2.44E-09	7.66E-11
Nickel	4.06E-04	2.19E-06	8.09E-09
Selenium	3.49E-04	3.62E-09	1.14E-10
Silver	2.21E-05	4.15E-07	5.21E-10
Strontium	1.45E-03	9.59E-07	3.01E-09
Thallium	1.08E-05	1.54E-10	4.83E-12
Uranium	6.04E-06	N/A	N/A
Vanadium	6.26E-05	5.38E-07	1.69E-09
Zinc	6.49E-01	2.46E-05	7.71E-08

Note: N/A – not assessed due to lack of data

Table B.6 Calculated Intakes (Carcinogenic) for Composite Receptor at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	Fish	Hare	Marmot	Beaver	Moose	Caribou	Sheep	Grouse	Mallard	Lab Tea	Berries	Soil
Antimony	7.93E-06	2.06E-06	5.98E-07	2.51E-07	3.16E-05	1.28E-05	2.34E-06	7.14E-08	5.02E-07	2.76E-07	6.46E-08	1.07E-07	1.99E-07
Arsenic	2.38E-05	3.21E-05	5.17E-06	2.09E-06	7.55E-06	1.02E-04	2.07E-05	6.09E-07	5.30E-06	1.61E-05	6.46E-08	1.07E-07	1.07E-06
Barium	2.21E-04	6.98E-05	5.34E-06	5.31E-06	4.73E-05	5.20E-05	2.55E-06	1.10E-06	7.07E-07	2.29E-07	1.25E-04	2.19E-05	2.30E-06
Cadmium	2.13E-06	5.47E-05	4.21E-07	7.91E-08	5.80E-06	3.12E-05	6.21E-07	2.30E-08	2.69E-06	1.66E-06	1.29E-08	8.73E-07	1.56E-07
Chromium	2.43E-06	2.75E-05	2.85E-06	1.44E-06	1.27E-05	3.92E-05	3.69E-06	3.73E-07	8.79E-07	7.31E-08	3.51E-07	4.26E-07	1.70E-07
Cobalt	5.18E-06	1.51E-05	4.12E-07	1.42E-07	6.54E-06	4.79E-06	2.49E-07	4.08E-08	1.86E-06	4.11E-07	6.46E-08	1.07E-07	3.26E-07
Copper	1.40E-05	8.61E-05	2.04E-05	1.56E-05	4.47E-04	5.43E-04	3.08E-05	3.45E-06	1.61E-06	5.35E-07	4.83E-06	1.08E-05	3.75E-07
Lead	2.54E-04	1.16E-04	5.78E-06	2.34E-06	7.87E-05	2.72E-04	8.24E-05	6.82E-07	3.37E-06	4.19E-06	2.24E-07	1.07E-07	3.40E-06
Manganese	1.22E-03	1.86E-03	1.59E-04	1.00E-04	1.57E-03	2.00E-03	1.95E-04	2.16E-05	7.06E-07	3.62E-07	4.95E-04	2.94E-04	2.71E-05
Mercury	5.39E-08	2.10E-05	3.75E-08	2.42E-08	1.23E-06	1.93E-06	1.18E-07	5.41E-09	1.52E-10	1.07E-10	6.46E-09	1.07E-08	5.99E-10
Molybdenum	1.86E-06	5.48E-05	1.03E-07	3.98E-08	4.14E-06	4.77E-06	8.51E-08	9.05E-09	3.28E-08	1.60E-08	1.00E-07	7.82E-07	1.15E-08
Nickel	2.89E-05	2.91E-04	1.77E-05	6.70E-06	6.81E-05	1.66E-04	7.78E-06	1.88E-06	2.18E-06	2.07E-07	6.14E-07	3.13E-06	1.22E-06
Selenium	1.25E-06	7.56E-05	1.11E-05	5.32E-06	1.08E-04	2.97E-04	7.99E-06	1.22E-06	1.76E-06	2.47E-06	1.29E-07	2.13E-07	1.71E-08
Silver	3.21E-06	2.41E-06	3.99E-07	1.62E-07	6.07E-06	1.72E-05	2.37E-06	4.70E-08	1.56E-07	1.12E-07	6.46E-09	1.07E-08	7.84E-08
Strontium	5.55E-04	6.05E-04	9.94E-06	3.51E-06	4.09E-04	4.67E-04	4.89E-06	7.67E-07	2.78E-07	1.05E-06	7.62E-06	2.62E-06	4.53E-07
Thallium	8.88E-08	3.27E-06	3.90E-07	4.61E-07	2.30E-06	6.91E-06	1.11E-06	9.49E-08	1.58E-07	9.34E-07	5.14E-08	2.13E-08	7.27E-10
Uranium	2.94E-06	1.72E-07	3.86E-09	3.07E-09	5.96E-07	4.42E-06	4.84E-09	6.29E-10	8.45E-09	3.44E-07	2.58E-08	4.26E-08	N/A
Vanadium	2.05E-06	8.60E-06	1.80E-06	8.35E-07	2.86E-05	4.34E-05	1.85E-06	2.24E-07	1.80E-06	1.48E-06	3.22E-07	5.33E-07	2.54E-07
Zinc	2.39E-04	8.91E-03	1.17E-02	3.90E-03	1.17E-01	7.94E-01	1.43E-02	9.49E-04	6.02E-05	5.75E-05	4.66E-05	4.45E-05	1.16E-05

Note: N/A – not assessed due to lack of data

Table B.6 (Cont'd) Calculated Intakes (Carcinogenic) for Composite Receptor at the Historic Keno Hill Mine Site - South McQuesten Area

COPC	Total Ingestion	Total Dermal	Inhalation
	(mg/(kg-d))	(mg/(kg-d))	(mg/m^3)
Antimony	5.88E-05	5.84E-07	1.72E-09
Arsenic	2.17E-04	9.46E-07	9.29E-09
Barium	5.54E-04	6.76E-06	1.99E-08
Cadmium	1.00E-04	4.57E-08	1.35E-09
Chromium	9.21E-05	5.00E-07	1.48E-09
Cobalt	3.52E-05	9.56E-07	2.82E-09
Copper	1.18E-03	6.60E-07	3.24E-09
Lead	8.23E-04	6.00E-07	2.95E-08
Manganese	7.94E-03	7.96E-05	2.35E-07
Mercury	2.44E-05	1.76E-09	5.18E-12
Molybdenum	6.68E-05	3.39E-09	9.99E-11
Nickel	5.95E-04	3.04E-06	1.05E-08
Selenium	5.12E-04	5.02E-09	1.48E-10
Silver	3.22E-05	5.76E-07	6.79E-10
Strontium	2.07E-03	1.33E-06	3.92E-09
Thallium	1.58E-05	2.14E-10	6.30E-12
Uranium	8.56E-06	N/A	N/A
Vanadium	9.18E-05	7.46E-07	2.20E-09
Zinc	9.51E-01	3.41E-05	1.01E-07

Note: N/A – not assessed due to lack of data

Table B.7 Calculated Intakes (Non-carcinogenic) for Toddler at the Historic Keno Hill Mine Site - Galena Hill Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	2.97E-06	4.58E-06	1.51E-07	7.67E-08	9.52E-06	2.55E-05	4.66E-06	1.92E-08	1.12E-07	5.50E-07	-	3.46E-07	1.61E-07
Arsenic	7.18E-05	1.41E-04	2.02E-06	8.47E-07	2.05E-05	2.04E-04	4.13E-05	2.42E-07	2.04E-06	3.21E-05	-	3.46E-07	1.82E-06
Barium	3.24E-04	8.82E-04	1.82E-05	4.25E-06	1.28E-04	1.04E-04	5.09E-06	1.01E-06	4.33E-06	4.57E-07	-	7.13E-05	5.60E-05
Cadmium	1.02E-06	6.57E-05	7.15E-07	2.34E-08	7.85E-06	6.21E-05	1.24E-06	6.56E-09	4.37E-06	3.32E-06	-	2.84E-06	1.84E-07
Chromium	1.52E-05	4.25E-05	4.48E-06	1.86E-06	3.80E-05	7.81E-05	7.36E-06	5.31E-07	1.52E-06	1.46E-07	-	1.38E-06	1.46E-06
Cobalt	1.06E-05	5.20E-05	3.14E-07	7.44E-08	1.20E-05	9.54E-06	4.97E-07	2.06E-08	1.35E-06	8.20E-07	-	3.46E-07	6.74E-07
Copper	4.86E-05	2.72E-04	1.79E-05	5.43E-06	8.46E-04	1.08E-03	6.13E-05	1.57E-06	2.17E-06	1.07E-06	-	3.49E-05	2.70E-06
Lead	2.11E-04	1.33E-04	1.98E-06	8.08E-07	4.19E-05	5.41E-04	1.64E-04	2.33E-07	1.14E-06	8.35E-06	-	3.46E-07	5.10E-06
Manganese	3.65E-04	2.89E-03	1.93E-04	1.35E-04	1.05E-03	3.99E-03	3.88E-04	2.80E-05	7.65E-07	7.22E-07	-	9.55E-04	5.77E-05
Mercury	4.55E-08	1.99E-05	8.01E-08	4.56E-08	1.33E-06	3.85E-06	2.35E-07	1.07E-08	3.54E-10	2.14E-10	-	3.46E-08	7.59E-09
Molybdenum	2.53E-06	5.59E-05	1.28E-07	5.73E-08	6.57E-06	9.51E-06	1.70E-07	1.41E-08	4.49E-08	3.20E-08	-	2.54E-06	1.29E-07
Nickel	2.26E-05	3.04E-04	1.07E-05	3.17E-06	7.91E-05	3.31E-04	1.55E-05	8.30E-07	1.26E-06	4.13E-07	-	1.02E-05	1.97E-06
Selenium	3.02E-06	9.74E-04	1.38E-05	8.27E-06	1.39E-04	5.91E-04	1.59E-05	1.88E-06	2.10E-06	4.92E-06	-	6.92E-07	1.09E-07
Silver	3.57E-06	3.92E-06	2.44E-07	1.00E-07	7.72E-06	3.43E-05	4.73E-06	2.88E-08	9.42E-08	2.24E-07	-	3.46E-08	2.11E-07
Strontium	3.95E-04	3.82E-03	2.97E-05	5.37E-06	5.17E-04	9.31E-04	9.75E-06	1.22E-06	9.12E-07	2.09E-06	-	8.52E-06	5.34E-06
Thallium	1.97E-07	1.63E-06	5.63E-07	6.39E-07	1.39E-06	1.38E-05	2.22E-06	1.33E-07	2.51E-07	1.86E-06	-	6.92E-08	6.39E-09
Uranium	2.84E-06	2.19E-06	6.84E-09	5.10E-09	1.31E-06	8.81E-06	9.65E-09	1.05E-09	1.57E-08	6.87E-07	-	1.38E-07	N/A
Vanadium	2.18E-05	4.58E-05	3.49E-06	1.57E-06	1.89E-04	8.65E-05	3.68E-06	4.26E-07	3.52E-06	2.95E-06	-	1.73E-06	2.27E-06
Zinc	1.66E-04	1.03E-02	7.77E-03	1.42E-03	1.48E-01	1.58E+00	2.85E-02	3.23E-04	4.03E-05	1.15E-04	-	1.45E-04	1.16E-05

Note: N/A – not assessed due to lack of data
"-" – pathway not assessed for this receptor

Table B.7 (Cont'd) Calculated Intakes (Non-carcinogenic) for Toddler at the Historic Keno Hill Mine Site – Galena Hill Area

COPC	Total Ingestion (mg/(kg-d))	Total Dermal (mg/(kg-d))	Inhalation (mg/m^3)
Antimony	4.86E-05	8.53E-08	1.56E-10
Arsenic	5.18E-04	2.89E-07	1.76E-09
Barium	1.60E-03	2.97E-05	5.40E-08
Cadmium	1.49E-04	9.76E-09	1.78E-10
Chromium	1.93E-04	7.72E-07	1.41E-09
Cobalt	8.82E-05	3.57E-07	6.51E-10
Copper	2.38E-03	8.56E-07	2.60E-09
Lead	1.11E-03	1.62E-07	4.92E-09
Manganese	1.01E-02	3.06E-05	5.57E-08
Mercury	2.56E-05	4.02E-09	7.32E-12
Molybdenum	7.76E-05	6.84E-09	1.25E-10
Nickel	7.81E-04	8.87E-07	1.90E-09
Selenium	1.76E-03	5.75E-09	1.05E-10
Silver	5.51E-05	2.80E-07	2.04E-10
Strontium	5.73E-03	2.82E-06	5.15E-09
Thallium	2.27E-05	3.38E-10	6.17E-12
Uranium	1.60E-05	N/A	N/A
Vanadium	3.63E-04	1.20E-06	2.19E-09
Zinc	1.78E+00	6.16E-06	1.12E-08

Note: N/A – not assessed due to lack of data

Table B.8 Calculated Intakes (Non-carcinogenic) for Child at the Historic Keno Hill Mine Site - Galena Hill Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	1.99E-06	3.72E-06	1.07E-07	5.48E-08	6.80E-06	1.82E-05	3.33E-06	1.37E-08	8.00E-08	3.93E-07	-	1.97E-07	7.46E-08
Arsenic	4.80E-05	1.15E-04	1.44E-06	6.05E-07	1.47E-05	1.45E-04	2.95E-05	1.73E-07	1.45E-06	2.29E-05	-	1.97E-07	8.43E-07
Barium	2.16E-04	7.17E-04	1.30E-05	3.03E-06	9.12E-05	7.40E-05	3.63E-06	7.20E-07	3.09E-06	3.26E-07	-	4.06E-05	2.59E-05
Cadmium	6.85E-07	5.34E-05	5.11E-07	1.67E-08	5.60E-06	4.43E-05	8.84E-07	4.68E-09	3.12E-06	2.37E-06	-	1.62E-06	8.54E-08
Chromium	1.02E-05	3.45E-05	3.19E-06	1.33E-06	2.71E-05	5.58E-05	5.25E-06	3.79E-07	1.08E-06	1.04E-07	-	7.88E-07	6.76E-07
Cobalt	7.11E-06	4.22E-05	2.24E-07	5.31E-08	8.53E-06	6.81E-06	3.55E-07	1.47E-08	9.64E-07	5.85E-07	-	1.97E-07	3.12E-07
Copper	3.25E-05	2.21E-04	1.28E-05	3.88E-06	6.04E-04	7.72E-04	4.38E-05	1.12E-06	1.55E-06	7.62E-07	-	1.99E-05	1.25E-06
Lead	1.41E-04	1.08E-04	1.41E-06	5.77E-07	2.99E-05	3.86E-04	1.17E-04	1.66E-07	8.16E-07	5.96E-06	-	1.97E-07	2.36E-06
Manganese	2.44E-04	2.35E-03	1.38E-04	9.65E-05	7.51E-04	2.84E-03	2.77E-04	2.00E-05	5.46E-07	5.15E-07	-	5.44E-04	2.67E-05
Mercury	3.04E-08	1.62E-05	5.72E-08	3.26E-08	9.47E-07	2.75E-06	1.68E-07	7.62E-09	2.53E-10	1.53E-10	-	1.97E-08	3.52E-09
Molybdenum	1.69E-06	4.54E-05	9.12E-08	4.09E-08	4.69E-06	6.78E-06	1.21E-07	1.00E-08	3.21E-08	2.28E-08	-	1.45E-06	5.99E-08
Nickel	1.51E-05	2.47E-04	7.63E-06	2.26E-06	5.64E-05	2.36E-04	1.11E-05	5.92E-07	8.98E-07	2.95E-07	-	5.79E-06	9.13E-07
Selenium	2.02E-06	7.91E-04	9.85E-06	5.90E-06	9.94E-05	4.22E-04	1.14E-05	1.34E-06	1.50E-06	3.51E-06	-	3.94E-07	5.03E-08
Silver	2.39E-06	3.19E-06	1.74E-07	7.17E-08	5.51E-06	2.45E-05	3.38E-06	2.06E-08	6.72E-08	1.60E-07	-	1.97E-08	9.78E-08
Strontium	2.64E-04	3.11E-03	2.12E-05	3.83E-06	3.69E-04	6.65E-04	6.96E-06	8.73E-07	6.51E-07	1.49E-06	-	4.85E-06	2.47E-06
Thallium	1.32E-07	1.33E-06	4.02E-07	4.56E-07	9.94E-07	9.83E-06	1.59E-06	9.47E-08	1.79E-07	1.33E-06	-	3.94E-08	2.96E-09
Uranium	1.90E-06	1.78E-06	4.88E-09	3.64E-09	9.36E-07	6.29E-06	6.88E-09	7.52E-10	1.12E-08	4.90E-07	-	7.88E-08	N/A
Vanadium	1.46E-05	3.72E-05	2.49E-06	1.12E-06	1.35E-04	6.18E-05	2.63E-06	3.04E-07	2.51E-06	2.10E-06	-	9.86E-07	1.05E-06
Zinc	1.11E-04	8.36E-03	5.54E-03	1.01E-03	1.06E-01	1.13E+00	2.03E-02	2.31E-04	2.88E-05	8.19E-05	-	8.24E-05	5.38E-06

Note: N/A – not assessed due to lack of data
"-" – pathway not assessed for this receptor

Table B.8 (Cont'd) Calculated Intakes (Non-carcinogenic) for Child at the Historic Keno Hill Mine Site – Galena Hill Area

COPC	Total Ingestion (mg/(kg-d))	Total Dermal (mg/(kg-d))	Inhalation (mg/m^3)
Antimony	3.49E-05	6.50E-08	1.56E-10
Arsenic	3.80E-04	2.20E-07	1.76E-09
Barium	1.19E-03	2.26E-05	5.40E-08
Cadmium	1.13E-04	7.44E-09	1.78E-10
Chromium	1.40E-04	5.88E-07	1.41E-09
Cobalt	6.74E-05	2.72E-07	6.51E-10
Copper	1.71E-03	6.52E-07	2.60E-09
Lead	7.95E-04	1.23E-07	4.92E-09
Manganese	7.29E-03	2.33E-05	5.57E-08
Mercury	2.02E-05	3.06E-09	7.32E-12
Molybdenum	6.04E-05	5.21E-09	1.25E-10
Nickel	5.84E-04	6.76E-07	1.90E-09
Selenium	1.35E-03	4.38E-09	1.05E-10
Silver	3.95E-05	2.13E-07	2.04E-10
Strontium	4.45E-03	2.15E-06	5.15E-09
Thallium	1.64E-05	2.58E-10	6.17E-12
Uranium	1.15E-05	N/A	N/A
Vanadium	2.62E-04	9.14E-07	2.19E-09
Zinc	1.27E+00	4.69E-06	1.12E-08

Note: N/A – not assessed due to lack of data

Table B.9 Calculated Intakes (Non-carcinogenic) for Teen at the Historic Keno Hill Mine Site - Galena Hill Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	1.37E-06	2.53E-06	8.00E-08	4.08E-08	5.06E-06	1.35E-05	2.48E-06	1.02E-08	5.96E-08	2.93E-07	7.00E-08	9.97E-08	5.14E-09
Arsenic	3.31E-05	7.80E-05	1.08E-06	4.50E-07	1.09E-05	1.08E-04	2.20E-05	1.29E-07	1.08E-06	1.70E-05	7.00E-08	9.97E-08	5.81E-08
Barium	1.49E-04	4.88E-04	9.68E-06	2.26E-06	6.79E-05	5.51E-05	2.70E-06	5.36E-07	2.30E-06	2.43E-07	4.38E-05	2.05E-05	1.79E-06
Cadmium	4.72E-07	3.63E-05	3.80E-07	1.24E-08	4.17E-06	3.30E-05	6.59E-07	3.49E-09	2.32E-06	1.76E-06	1.40E-08	8.17E-07	5.88E-09
Chromium	6.99E-06	2.35E-05	2.38E-06	9.90E-07	2.02E-05	4.15E-05	3.91E-06	2.82E-07	8.08E-07	7.74E-08	7.00E-08	3.99E-07	4.65E-08
Cobalt	4.90E-06	2.87E-05	1.67E-07	3.95E-08	6.35E-06	5.07E-06	2.64E-07	1.10E-08	7.18E-07	4.36E-07	7.00E-08	9.97E-08	2.15E-08
Copper	2.24E-05	1.50E-04	9.52E-06	2.89E-06	4.50E-04	5.75E-04	3.26E-05	8.32E-07	1.15E-06	5.67E-07	7.00E-08	1.01E-05	8.60E-08
Lead	9.74E-05	7.37E-05	1.05E-06	4.29E-07	2.23E-05	2.88E-04	8.73E-05	1.24E-07	6.08E-07	4.44E-06	1.27E-07	9.97E-08	1.63E-07
Manganese	1.68E-04	1.60E-03	1.03E-04	7.19E-05	5.60E-04	2.12E-03	2.06E-04	1.49E-05	4.07E-07	3.84E-07	5.04E-04	2.75E-04	1.84E-06
Mercury	2.09E-08	1.10E-05	4.26E-08	2.43E-08	7.05E-07	2.05E-06	1.25E-07	5.67E-09	1.88E-10	1.14E-10	7.00E-09	9.97E-09	2.42E-10
Molybdenum	1.17E-06	3.09E-05	6.79E-08	3.04E-08	3.49E-06	5.05E-06	9.01E-08	7.47E-09	2.39E-08	1.70E-08	7.00E-08	7.32E-07	4.12E-09
Nickel	1.04E-05	1.68E-04	5.68E-06	1.69E-06	4.20E-05	1.76E-04	8.24E-06	4.41E-07	6.69E-07	2.20E-07	5.13E-07	2.93E-06	6.29E-08
Selenium	1.39E-06	5.38E-04	7.34E-06	4.39E-06	7.41E-05	3.14E-04	8.47E-06	9.99E-07	1.12E-06	2.61E-06	1.40E-07	1.99E-07	3.47E-09
Silver	1.65E-06	2.17E-06	1.30E-07	5.34E-08	4.10E-06	1.82E-05	2.52E-06	1.53E-08	5.00E-08	1.19E-07	7.00E-09	9.97E-09	6.74E-09
Strontium	1.82E-04	2.11E-03	1.58E-05	2.86E-06	2.75E-04	4.95E-04	5.18E-06	6.50E-07	4.85E-07	1.11E-06	6.89E-06	2.45E-06	1.70E-07
Thallium	9.07E-08	9.03E-07	2.99E-07	3.40E-07	7.41E-07	7.32E-06	1.18E-06	7.05E-08	1.33E-07	9.90E-07	4.71E-08	1.99E-08	2.04E-10
Uranium	1.31E-06	1.21E-06	3.64E-09	2.71E-09	6.97E-07	4.68E-06	5.13E-09	5.60E-10	8.35E-09	3.65E-07	2.80E-08	3.99E-08	N/A
Vanadium	1.01E-05	2.53E-05	1.86E-06	8.34E-07	1.00E-04	4.60E-05	1.96E-06	2.26E-07	1.87E-06	1.57E-06	3.50E-07	4.98E-07	7.23E-08
Zinc	7.64E-05	5.69E-03	4.13E-03	7.55E-04	7.89E-02	8.42E-01	1.52E-02	1.72E-04	2.14E-05	6.10E-05	1.51E-05	4.17E-05	3.71E-07

Note: N/A – not assessed due to lack of data

Table B.9 (Cont'd) Calculated Intakes (Non-carcinogenic) for Teen at the Historic Keno Hill Mine Site – Galena Hill Area

COPC	Total Ingestion (mg/(kg-d))	Total Dermal (mg/(kg-d))	Inhalation (mg/m^3)
Antimony	2.56E-05	5.21E-08	1.56E-10
Arsenic	2.72E-04	1.77E-07	1.76E-09
Barium	8.44E-04	1.81E-05	5.40E-08
Cadmium	7.99E-05	5.96E-09	1.78E-10
Chromium	1.01E-04	4.72E-07	1.41E-09
Cobalt	4.69E-05	2.18E-07	6.51E-10
Copper	1.26E-03	5.23E-07	2.60E-09
Lead	5.76E-04	9.89E-08	4.92E-09
Manganese	5.62E-03	1.87E-05	5.57E-08
Mercury	1.40E-05	2.45E-09	7.32E-12
Molybdenum	4.16E-05	4.18E-09	1.25E-10
Nickel	4.17E-04	5.42E-07	1.90E-09
Selenium	9.53E-04	3.51E-09	1.05E-10
Silver	2.90E-05	1.71E-07	2.04E-10
Strontium	3.10E-03	1.72E-06	5.15E-09
Thallium	1.21E-05	2.07E-10	6.17E-12
Uranium	8.35E-06	N/A	N/A
Vanadium	1.91E-04	7.33E-07	2.19E-09
Zinc	9.47E-01	3.76E-06	1.12E-08

Note: N/A – not assessed due to lack of data

Table B.10 Calculated Intakes (Non-carcinogenic) for Adult at the Historic Keno Hill Mine Site - Galena Hill Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	1.73E-06	2.14E-06	6.75E-08	3.44E-08	4.27E-06	1.14E-05	2.09E-06	8.63E-09	5.03E-08	2.47E-07	5.91E-08	8.42E-08	4.92E-09
Arsenic	4.19E-05	6.59E-05	9.08E-07	3.80E-07	9.22E-06	9.14E-05	1.85E-05	1.09E-07	9.14E-07	1.44E-05	5.91E-08	8.42E-08	5.56E-08
Barium	1.89E-04	4.12E-04	8.17E-06	1.91E-06	5.73E-05	4.65E-05	2.28E-06	4.53E-07	1.94E-06	2.05E-07	3.70E-05	1.73E-05	1.71E-06
Cadmium	5.98E-07	3.07E-05	3.21E-07	1.05E-08	3.52E-06	2.79E-05	5.56E-07	2.94E-09	1.96E-06	1.49E-06	1.18E-08	6.90E-07	5.63E-09
Chromium	8.86E-06	1.98E-05	2.01E-06	8.36E-07	1.71E-05	3.51E-05	3.30E-06	2.38E-07	6.82E-07	6.54E-08	5.91E-08	3.37E-07	4.45E-08
Cobalt	6.21E-06	2.43E-05	1.41E-07	3.34E-08	5.36E-06	4.28E-06	2.23E-07	9.25E-09	6.06E-07	3.68E-07	5.91E-08	8.42E-08	2.06E-08
Copper	2.84E-05	1.27E-04	8.04E-06	2.44E-06	3.80E-04	4.86E-04	2.75E-05	7.03E-07	9.72E-07	4.79E-07	5.91E-08	8.50E-06	8.23E-08
Lead	1.23E-04	6.22E-05	8.89E-07	3.63E-07	1.88E-05	2.43E-04	7.37E-05	1.04E-07	5.13E-07	3.75E-06	1.07E-07	8.42E-08	1.56E-07
Manganese	2.13E-04	1.35E-03	8.67E-05	6.07E-05	4.72E-04	1.79E-03	1.74E-04	1.25E-05	3.43E-07	3.24E-07	4.26E-04	2.32E-04	1.76E-06
Mercury	2.65E-08	9.31E-06	3.59E-08	2.05E-08	5.95E-07	1.73E-06	1.06E-07	4.79E-09	1.59E-10	9.60E-11	5.91E-09	8.42E-09	2.32E-10
Molybdenum	1.48E-06	2.61E-05	5.74E-08	2.57E-08	2.95E-06	4.27E-06	7.61E-08	6.31E-09	2.02E-08	1.43E-08	5.91E-08	6.18E-07	3.95E-09
Nickel	1.32E-05	1.42E-04	4.80E-06	1.42E-06	3.55E-05	1.49E-04	6.96E-06	3.73E-07	5.65E-07	1.86E-07	4.33E-07	2.47E-06	6.02E-08
Selenium	1.76E-06	4.55E-04	6.20E-06	3.71E-06	6.25E-05	2.65E-04	7.15E-06	8.44E-07	9.42E-07	2.21E-06	1.18E-07	1.68E-07	3.32E-09
Silver	2.09E-06	1.83E-06	1.10E-07	4.51E-08	3.47E-06	1.54E-05	2.12E-06	1.29E-08	4.23E-08	1.00E-07	5.91E-09	8.42E-09	6.45E-09
Strontium	2.30E-04	1.78E-03	1.33E-05	2.41E-06	2.32E-04	4.18E-04	4.38E-06	5.49E-07	4.09E-07	9.40E-07	5.82E-06	2.07E-06	1.63E-07
Thallium	1.15E-07	7.63E-07	2.53E-07	2.87E-07	6.25E-07	6.18E-06	9.97E-07	5.96E-08	1.13E-07	8.36E-07	3.98E-08	1.68E-08	1.95E-10
Uranium	1.66E-06	1.02E-06	3.07E-09	2.29E-09	5.89E-07	3.95E-06	4.33E-09	4.73E-10	7.05E-09	3.08E-07	2.36E-08	3.37E-08	N/A
Vanadium	1.27E-05	2.14E-05	1.57E-06	7.04E-07	8.48E-05	3.88E-05	1.65E-06	1.91E-07	1.58E-06	1.32E-06	2.96E-07	4.21E-07	6.92E-08
Zinc	9.68E-05	4.81E-03	3.49E-03	6.38E-04	6.66E-02	7.11E-01	1.28E-02	1.45E-04	1.81E-05	5.15E-05	1.27E-05	3.52E-05	3.55E-07

Note: N/A – not assessed due to lack of data

Table B.10 (Cont'd) Calculated Intakes (Non-carcinogenic) for Adult at the Historic Keno Hill Mine Site – Galena Hill Area

COPC	Total Ingestion (mg/(kg-d))	Total Dermal (mg/(kg-d))	Inhalation (mg/m^3)
Antimony	2.22E-05	4.95E-08	1.56E-10
Arsenic	2.44E-04	1.68E-07	1.76E-09
Barium	7.76E-04	1.72E-05	5.40E-08
Cadmium	6.77E-05	5.67E-09	1.78E-10
Chromium	8.84E-05	4.49E-07	1.41E-09
Cobalt	4.17E-05	2.07E-07	6.51E-10
Copper	1.07E-03	4.97E-07	2.60E-09
Lead	5.27E-04	9.41E-08	4.92E-09
Manganese	4.82E-03	1.77E-05	5.57E-08
Mercury	1.18E-05	2.33E-09	7.32E-12
Molybdenum	3.57E-05	3.97E-09	1.25E-10
Nickel	3.56E-04	5.15E-07	1.90E-09
Selenium	8.06E-04	3.34E-09	1.05E-10
Silver	2.52E-05	1.62E-07	2.04E-10
Strontium	2.69E-03	1.64E-06	5.15E-09
Thallium	1.03E-05	1.96E-10	6.17E-12
Uranium	7.61E-06	N/A	N/A
Vanadium	1.66E-04	6.97E-07	2.19E-09
Zinc	7.99E-01	3.57E-06	1.12E-08

Note: N/A – not assessed due to lack of data

Table B.11 Calculated Intakes (Carcinogenic) for Adult at the Historic Keno Hill Mine Site - Galena Hill Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	Fish	Hare	Marmot	Beaver	Moose	Caribou	Sheep	Grouse	Mallard	Lab Tea	Berries	Soil
Antimony	1.32E-06	1.63E-06	5.15E-08	2.63E-08	3.26E-06	8.71E-06	1.59E-06	6.58E-09	3.84E-08	1.88E-07	4.51E-08	6.42E-08	3.75E-09
Arsenic	3.20E-05	5.02E-05	6.93E-07	2.90E-07	7.03E-06	6.97E-05	1.41E-05	8.28E-08	6.97E-07	1.10E-05	4.51E-08	6.42E-08	4.24E-08
Barium	1.44E-04	3.14E-04	6.23E-06	1.45E-06	4.37E-05	3.55E-05	1.74E-06	3.45E-07	1.48E-06	1.56E-07	2.82E-05	1.32E-05	1.30E-06
Cadmium	4.56E-07	2.34E-05	2.45E-07	7.99E-09	2.69E-06	2.13E-05	4.24E-07	2.25E-09	1.49E-06	1.14E-06	9.01E-09	5.26E-07	4.29E-09
Chromium	6.75E-06	1.51E-05	1.53E-06	6.37E-07	1.30E-05	2.67E-05	2.52E-06	1.82E-07	5.20E-07	4.98E-08	4.51E-08	2.57E-07	3.40E-08
Cobalt	4.73E-06	1.85E-05	1.07E-07	2.55E-08	4.09E-06	3.27E-06	1.70E-07	7.06E-09	4.62E-07	2.81E-07	4.51E-08	6.42E-08	1.57E-08
Copper	2.16E-05	9.68E-05	6.13E-06	1.86E-06	2.89E-04	3.70E-04	2.10E-05	5.36E-07	7.41E-07	3.65E-07	4.51E-08	6.48E-06	6.27E-08
Lead	9.40E-05	4.75E-05	6.78E-07	2.76E-07	1.43E-05	1.85E-04	5.62E-05	7.96E-08	3.91E-07	2.86E-06	8.17E-08	6.42E-08	1.19E-07
Manganese	1.63E-04	1.03E-03	6.61E-05	4.63E-05	3.60E-04	1.36E-03	1.33E-04	9.57E-06	2.62E-07	2.47E-07	3.24E-04	1.77E-04	1.34E-06
Mercury	2.02E-08	7.10E-06	2.74E-08	1.56E-08	4.54E-07	1.32E-06	8.05E-08	3.65E-09	1.21E-10	7.32E-11	4.51E-09	6.42E-09	1.77E-10
Molybdenum	1.13E-06	1.99E-05	4.37E-08	1.96E-08	2.25E-06	3.25E-06	5.80E-08	4.81E-09	1.54E-08	1.09E-08	4.51E-08	4.71E-07	3.01E-09
Nickel	1.01E-05	1.08E-04	3.66E-06	1.09E-06	2.71E-05	1.13E-04	5.31E-06	2.84E-07	4.31E-07	1.41E-07	3.30E-07	1.88E-06	4.59E-08
Selenium	1.34E-06	3.47E-04	4.73E-06	2.83E-06	4.77E-05	2.02E-04	5.45E-06	6.44E-07	7.18E-07	1.68E-06	9.01E-08	1.28E-07	2.53E-09
Silver	1.59E-06	1.40E-06	8.35E-08	3.44E-08	2.64E-06	1.17E-05	1.62E-06	9.87E-09	3.22E-08	7.66E-08	4.51E-09	6.42E-09	4.92E-09
Strontium	1.76E-04	1.36E-03	1.02E-05	1.84E-06	1.77E-04	3.19E-04	3.34E-06	4.19E-07	3.12E-07	7.17E-07	4.43E-06	1.58E-06	1.24E-07
Thallium	8.76E-08	5.82E-07	1.93E-07	2.19E-07	4.77E-07	4.71E-06	7.60E-07	4.54E-08	8.59E-08	6.37E-07	3.03E-08	1.28E-08	1.49E-10
Uranium	1.27E-06	7.79E-07	2.34E-09	1.74E-09	4.49E-07	3.01E-06	3.30E-09	3.60E-10	5.38E-09	2.35E-07	1.80E-08	2.57E-08	N/A
Vanadium	9.71E-06	1.63E-05	1.19E-06	5.37E-07	6.47E-05	2.96E-05	1.26E-06	1.46E-07	1.20E-06	1.01E-06	2.25E-07	3.21E-07	5.28E-08
Zinc	7.38E-05	3.66E-03	2.66E-03	4.86E-04	5.08E-02	5.42E-01	9.76E-03	1.11E-04	1.38E-05	3.93E-05	9.70E-06	2.68E-05	2.71E-07

Note: N/A – not assessed due to lack of data

Table B.11 (Cont'd) Calculated Intakes (Carcinogenic) for Adult at the Historic Keno Hill Mine Site – Galena Hill Area

COPC	Total Ingestion	Total Dermal	Inhalation
	(mg/(kg-d))	(mg/(kg-d))	(mg/m^3)
Antimony	1.69E-05	3.78E-08	1.19E-10
Arsenic	1.86E-04	1.28E-07	1.34E-09
Barium	5.91E-04	1.31E-05	4.12E-08
Cadmium	5.16E-05	4.32E-09	1.36E-10
Chromium	6.74E-05	3.42E-07	1.07E-09
Cobalt	3.18E-05	1.58E-07	4.96E-10
Copper	8.15E-04	3.79E-07	1.98E-09
Lead	4.02E-04	7.17E-08	3.75E-09
Manganese	3.67E-03	1.35E-05	4.25E-08
Mercury	9.03E-06	1.78E-09	5.58E-12
Molybdenum	2.72E-05	3.03E-09	9.51E-11
Nickel	2.72E-04	3.93E-07	1.45E-09
Selenium	6.14E-04	2.55E-09	8.00E-11
Silver	1.92E-05	1.24E-07	1.55E-10
Strontium	2.05E-03	1.25E-06	3.92E-09
Thallium	7.84E-06	1.50E-10	4.70E-12
Uranium	5.80E-06	N/A	N/A
Vanadium	1.26E-04	5.32E-07	1.67E-09
Zinc	6.10E-01	2.73E-06	8.55E-09

Note: N/A – not assessed due to lack of data

Table B.12 Calculated Intakes (Carcinogenic) for Composite Receptor at the Historic Keno Hill Mine Site - Galena Hill Area

COPC	Intake Through Ingestion Pathways (mg/(kg-d))												
	Water	**Fish**	**Hare**	**Marmot**	**Beaver**	**Moose**	**Caribou**	**Sheep**	**Grouse**	**Mallard**	**Lab Tea**	**Berries**	**Soil**
Antimony	1.76E-06	2.41E-06	7.55E-08	3.85E-08	4.78E-06	1.28E-05	2.34E-06	9.64E-09	5.62E-08	2.76E-07	5.21E-08	1.07E-07	1.78E-08
Arsenic	4.26E-05	7.43E-05	1.02E-06	4.25E-07	1.03E-05	1.02E-04	2.07E-05	1.21E-07	1.02E-06	1.61E-05	5.21E-08	1.07E-07	2.02E-07
Barium	1.92E-04	4.64E-04	9.14E-06	2.13E-06	6.41E-05	5.20E-05	2.55E-06	5.06E-07	2.17E-06	2.29E-07	3.26E-05	2.19E-05	6.20E-06
Cadmium	6.08E-07	3.46E-05	3.59E-07	1.17E-08	3.94E-06	3.12E-05	6.21E-07	3.29E-09	2.19E-06	1.66E-06	1.04E-08	8.73E-07	2.04E-08
Chromium	9.01E-06	2.23E-05	2.25E-06	9.34E-07	1.91E-05	3.92E-05	3.69E-06	2.66E-07	7.62E-07	7.31E-08	5.21E-08	4.26E-07	1.62E-07
Cobalt	6.31E-06	2.73E-05	1.58E-07	3.73E-08	6.00E-06	4.79E-06	2.49E-07	1.03E-08	6.78E-07	4.11E-07	5.21E-08	1.07E-07	7.47E-08
Copper	2.89E-05	1.43E-04	8.98E-06	2.72E-06	4.24E-04	5.43E-04	3.08E-05	7.85E-07	1.09E-06	5.35E-07	5.21E-08	1.08E-05	2.99E-07
Lead	1.25E-04	7.01E-05	9.93E-07	4.05E-07	2.10E-05	2.72E-04	8.24E-05	1.17E-07	5.74E-07	4.19E-06	9.44E-08	1.07E-07	5.65E-07
Manganese	2.17E-04	1.52E-03	9.69E-05	6.78E-05	5.28E-04	2.00E-03	1.95E-04	1.40E-05	3.84E-07	3.62E-07	3.75E-04	2.94E-04	6.39E-06
Mercury	2.70E-08	1.05E-05	4.02E-08	2.29E-08	6.65E-07	1.93E-06	1.18E-07	5.35E-09	1.78E-10	1.07E-10	5.21E-09	1.07E-08	8.41E-10
Molybdenum	1.50E-06	2.94E-05	6.41E-08	2.87E-08	3.30E-06	4.77E-06	8.51E-08	7.05E-09	2.25E-08	1.60E-08	5.21E-08	7.82E-07	1.43E-08
Nickel	1.34E-05	1.60E-04	5.36E-06	1.59E-06	3.96E-05	1.66E-04	7.78E-06	4.16E-07	6.31E-07	2.07E-07	3.82E-07	3.13E-06	2.18E-07
Selenium	1.79E-06	5.12E-04	6.93E-06	4.15E-06	6.99E-05	2.97E-04	7.99E-06	9.43E-07	1.05E-06	2.47E-06	1.04E-07	2.13E-07	1.20E-08
Silver	2.12E-06	2.06E-06	1.22E-07	5.04E-08	3.87E-06	1.72E-05	2.37E-06	1.45E-08	4.72E-08	1.12E-07	5.21E-09	1.07E-08	2.34E-08
Strontium	2.34E-04	2.01E-03	1.49E-05	2.69E-06	2.59E-04	4.67E-04	4.89E-06	6.14E-07	4.57E-07	1.05E-06	5.12E-06	2.62E-06	5.91E-07
Thallium	1.17E-07	8.60E-07	2.82E-07	3.21E-07	6.99E-07	6.91E-06	1.11E-06	6.66E-08	1.26E-07	9.34E-07	3.51E-08	2.13E-08	7.08E-10
Uranium	1.69E-06	1.15E-06	3.43E-09	2.56E-09	6.58E-07	4.42E-06	4.84E-09	5.28E-10	7.88E-09	3.44E-07	2.08E-08	4.26E-08	N/A
Vanadium	1.29E-05	2.41E-05	1.75E-06	7.87E-07	9.48E-05	4.34E-05	1.85E-06	2.14E-07	1.76E-06	1.48E-06	2.60E-07	5.33E-07	2.51E-07
Zinc	9.84E-05	5.42E-03	3.90E-03	7.13E-04	7.45E-02	7.94E-01	1.43E-02	1.62E-04	2.02E-05	5.75E-05	1.12E-05	4.45E-05	1.29E-06

Note: N/A – not assessed due to lack of data

Table B.12 (Cont'd) Calculated Intakes (Carcinogenic) for Composite Receptor at the Historic Keno Hill Mine Site – Galena Hill Area

COPC	Total Ingestion	Total Dermal	Inhalation
	(mg/(kg-d))	(mg/(kg-d))	(mg/m^3)
Antimony	2.47E-05	5.24E-08	1.55E-10
Arsenic	2.69E-04	1.78E-07	1.75E-09
Barium	8.50E-04	1.82E-05	5.37E-08
Cadmium	7.60E-05	6.00E-09	1.77E-10
Chromium	9.82E-05	4.74E-07	1.40E-09
Cobalt	4.62E-05	2.19E-07	6.46E-10
Copper	1.19E-03	5.26E-07	2.58E-09
Lead	5.78E-04	9.95E-08	4.89E-09
Manganese	5.31E-03	1.88E-05	5.53E-08
Mercury	1.33E-05	2.47E-09	7.28E-12
Molybdenum	4.00E-05	4.20E-09	1.24E-10
Nickel	3.99E-04	5.45E-07	1.89E-09
Selenium	9.04E-04	3.53E-09	1.04E-10
Silver	2.80E-05	1.72E-07	2.03E-10
Strontium	3.00E-03	1.73E-06	5.11E-09
Thallium	1.15E-05	2.08E-10	6.13E-12
Uranium	8.34E-06	N/A	N/A
Vanadium	1.84E-04	7.37E-07	2.17E-09
Zinc	8.93E-01	3.78E-06	1.11E-08

Note: N/A – not assessed due to lack of data

B.2 ECOLOGICAL RECEPTOR RESULTS

Table B.13 Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Antimony	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	4.74E-05	1.47E-04	8.98E-05	7.88E-05	2.73E-04	3.52E-05	1.09E-04	6.67E-05	5.86E-05	2.03E-04
Soil	6.66E-03	6.66E-03	1.58E-01	1.11E-02	7.42E-02	1.11E-02	1.11E-02	2.63E-01	1.84E-02	1.23E-01
Fish										
Forage	1.22E-03	2.44E-02	2.67E-02	1.40E-03	1.51E-03					
Browse	1.93E-03	4.04E-02	3.41E-02	1.93E-03	2.11E-03	2.85E-03	5.97E-02	5.04E-02	2.85E-03	3.12E-03
Berries						2.51E-04	2.18E-04	2.27E-03	2.27E-03	2.51E-04
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	9.86E-03	7.16E-02	2.19E-01	1.45E-02	7.81E-02	1.42E-02	7.11E-02	3.16E-01	2.36E-02	1.27E-01

Arsenic	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	1.10E-03	1.36E-03	4.92E-04	3.15E-04	8.18E-04	8.15E-04	1.01E-03	3.66E-04	2.34E-04	6.08E-04
Soil	7.53E-02	7.53E-02	1.27E+00	1.11E-01	4.01E-01	1.25E-01	1.25E-01	2.11E+00	1.85E-01	6.67E-01
Fish										
Forage	1.22E-03	1.06E-01	6.83E-02	2.01E-03	1.51E-03					
Browse	1.93E-03	2.78E-01	1.31E-01	3.91E-03	2.30E-03	2.85E-03	4.11E-01	1.94E-01	5.78E-03	3.40E-03
Berries						2.51E-04	1.75E-03	7.25E-03	7.25E-03	2.51E-04
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	7.96E-02	4.61E-01	1.47E+00	1.18E-01	4.05E-01	1.29E-01	5.39E-01	2.31E+00	1.99E-01	6.71E-01

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Barium	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	5.62E-03	7.22E-03	5.50E-03	6.47E-03	7.61E-03	4.18E-03	5.37E-03	4.09E-03	4.81E-03	5.65E-03
Soil	2.32E+00	2.32E+00	2.45E+00	2.01E+00	8.59E-01	3.85E+00	3.85E+00	4.07E+00	3.34E+00	1.43E+00
Fish										
Forage	7.64E-01	1.69E+00	1.65E+00	2.43E+00	2.93E+00					
Browse	7.14E+00	4.89E+00	5.39E-01	6.02E-01	2.18E+00	1.06E+01	7.24E+00	7.98E-01	8.91E-01	3.22E+00
Berries						5.17E-02	2.88E-02	3.86E-02	3.86E-02	5.17E-02
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.02E+01	8.91E+00	4.65E+00	5.04E+00	5.98E+00	1.45E+01	1.11E+01	4.91E+00	4.27E+00	4.71E+00

Cadmium	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	2.36E-05	2.41E-04	7.80E-04	4.64E-05	7.33E-05	1.76E-05	1.79E-04	5.80E-04	3.45E-05	5.45E-05
Soil	7.63E-03	7.63E-03	1.36E-01	4.01E-03	5.81E-02	1.27E-02	1.27E-02	2.27E-01	6.67E-03	9.67E-02
Fish										
Forage	2.44E-04	5.66E-02	1.85E-02	6.14E-04	3.02E-04					
Browse	1.00E-01	2.13E+00	5.48E-01	1.31E-01	6.84E-02	1.48E-01	3.16E+00	8.10E-01	1.93E-01	1.01E-01
Berries						2.06E-03	1.40E-03	1.77E-03	1.77E-03	2.06E-03
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.08E-01	2.20E+00	7.04E-01	1.35E-01	1.27E-01	1.63E-01	3.17E+00	1.04E+00	2.02E-01	2.00E-01

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Chromium	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	2.29E-04	1.65E-04	2.17E-04	1.88E-04	8.36E-05	1.71E-04	1.23E-04	1.62E-04	1.39E-04	6.21E-05
Soil	6.03E-02	6.03E-02	6.12E-02	5.00E-02	6.36E-02	1.00E-01	1.00E-01	1.02E-01	8.31E-02	1.06E-01
Fish										
Forage	1.22E-03	1.22E-02	1.51E-02	3.30E-02	8.22E-03					
Browse	2.21E-03	1.35E-02	4.42E-02	2.04E-02	9.40E-03	3.27E-03	1.99E-02	6.54E-02	3.02E-02	1.39E-02
Berries						1.00E-03	4.36E-04	8.04E-04	8.04E-04	1.00E-03
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	6.40E-02	8.62E-02	1.21E-01	1.04E-01	8.13E-02	1.05E-01	1.21E-01	1.68E-01	1.14E-01	1.21E-01

Cobalt	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	1.72E-04	1.28E-04	1.19E-04	4.43E-05	1.78E-04	1.28E-04	9.53E-05	8.84E-05	3.29E-05	1.33E-04
Soil	2.79E-02	2.79E-02	1.02E-01	5.61E-02	1.22E-01	4.64E-02	4.64E-02	1.70E-01	9.33E-02	2.02E-01
Fish										
Forage	1.22E-03	1.04E-02	1.76E-03	1.22E-03	1.51E-03					
Browse	2.82E-02	4.53E-01	1.03E-02	6.35E-03	2.70E-02	4.16E-02	6.70E-01	1.52E-02	9.39E-03	3.99E-02
Berries						2.51E-04	2.18E-04	2.51E-04	2.51E-04	2.51E-04
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	5.74E-02	4.91E-01	1.14E-01	6.37E-02	1.50E-01	8.84E-02	7.17E-01	1.85E-01	1.03E-01	2.43E-01

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Copper	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	7.22E-04	4.85E-04	5.59E-04	3.88E-04	4.84E-04	5.37E-04	3.60E-04	4.16E-04	2.89E-04	3.60E-04
Soil	1.11E-01	1.11E-01	2.34E-01	1.51E-01	1.40E-01	1.85E-01	1.85E-01	3.90E-01	2.51E-01	2.33E-01
Fish										
Forage	1.22E-03	2.23E-01	1.72E-01	1.29E-01	1.13E-01					
Browse	4.31E-02	2.78E-01	2.22E-01	3.53E-01	1.01E-01	6.37E-02	4.11E-01	3.28E-01	5.22E-01	1.49E-01
Berries						2.53E-02	2.23E-02	2.80E-02	2.80E-02	2.53E-02
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.56E-01	6.13E-01	6.29E-01	6.33E-01	3.55E-01	2.75E-01	6.19E-01	7.46E-01	8.01E-01	4.08E-01

Lead	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	2.82E-03	2.03E-03	1.28E-03	1.28E-03	8.76E-03	2.10E-03	1.51E-03	9.53E-04	9.53E-04	6.51E-03
Soil	2.11E-01	2.11E-01	9.26E+00	2.04E-01	1.27E+00	3.51E-01	3.51E-01	1.54E+01	3.40E-01	2.11E+00
Fish										
Forage	2.21E-03	4.79E-01	1.33E+00	2.07E-02	5.26E-03					
Browse	6.57E-03	7.85E-01	1.07E+00	2.62E-02	9.37E-03	9.71E-03	1.16E+00	1.58E+00	3.88E-02	1.39E-02
Berries						2.51E-04	4.36E-03	2.47E-01	2.47E-01	2.51E-04
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	2.22E-01	1.48E+00	1.17E+01	2.52E-01	1.29E+00	3.63E-01	1.52E+00	1.72E+01	6.27E-01	2.13E+00

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Manganese	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	1.37E-02	8.92E-02	7.84E-02	6.73E-03	4.20E-02	1.02E-02	6.63E-02	5.83E-02	5.00E-03	3.12E-02
Soil	2.39E+00	2.39E+00	5.35E+01	1.20E+01	1.01E+01	3.97E+00	3.97E+00	8.91E+01	2.00E+01	1.68E+01
Fish										
Forage	8.79E+00	4.13E+01	1.05E+01	1.21E+01	1.16E+01					
Browse	1.41E+01	3.11E+01	7.64E+00	7.78E+00	1.99E+01	2.09E+01	4.59E+01	1.13E+01	1.15E+01	2.94E+01
Berries						6.92E-01	2.64E-01	4.20E-01	4.20E-01	6.92E-01
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	2.53E+01	7.48E+01	7.17E+01	3.19E+01	4.17E+01	2.56E+01	5.02E+01	1.01E+02	3.19E+01	4.70E+01

Mercury	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	9.29E-07	9.29E-07	9.29E-06	9.29E-06	1.86E-06	6.90E-07	6.90E-07	6.90E-06	6.90E-06	1.38E-06
Soil	3.14E-04	3.14E-04	9.32E-04	2.54E-04	2.24E-04	5.22E-04	5.22E-04	1.55E-03	4.23E-04	3.72E-04
Fish										
Forage	1.22E-04	2.06E-04	1.68E-04	2.12E-04	1.51E-04					
Browse	1.93E-04	2.80E-04	2.17E-04	1.93E-04	2.11E-04	2.85E-04	4.13E-04	3.21E-04	2.85E-04	3.12E-04
Berries						2.51E-05	2.18E-05	2.51E-05	2.51E-05	2.51E-05
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	6.30E-04	8.00E-04	1.33E-03	6.68E-04	5.88E-04	8.33E-04	9.58E-04	1.90E-03	7.41E-04	7.10E-04

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Molybdenum	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	4.91E-05	5.75E-05	4.29E-05	6.60E-05	6.41E-05	3.65E-05	4.27E-05	3.19E-05	4.91E-05	4.77E-05
Soil	5.35E-03	5.35E-03	1.03E-02	6.84E-03	4.31E-03	8.89E-03	8.89E-03	1.71E-02	1.14E-02	7.17E-03
Fish										
Forage	1.22E-03	2.06E-03	1.63E-03	3.82E-03	2.35E-03					
Browse	3.43E-03	3.36E-02	3.16E-02	2.30E-02	9.49E-03	5.08E-03	4.96E-02	4.68E-02	3.40E-02	1.40E-02
Berries						1.84E-03	2.18E-04	1.37E-03	1.37E-03	1.84E-03
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.00E-02	4.10E-02	4.36E-02	3.37E-02	1.62E-02	1.58E-02	5.88E-02	6.53E-02	4.68E-02	2.31E-02

Nickel	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	3.06E-04	5.95E-04	4.83E-04	2.41E-04	9.94E-04	2.28E-04	4.42E-04	3.59E-04	1.79E-04	7.39E-04
Soil	8.15E-02	8.15E-02	1.20E-01	9.76E-02	4.55E-01	1.36E-01	1.36E-01	2.00E-01	1.62E-01	7.57E-01
Fish										
Forage	8.96E-03	7.94E-02	1.62E-02	4.11E-02	1.44E-02					
Browse	7.74E-02	2.12E+00	8.28E-02	5.31E-02	8.58E-02	1.14E-01	3.14E+00	1.22E-01	7.85E-02	1.27E-01
Berries						7.37E-03	1.31E-03	2.62E-03	2.62E-03	7.37E-03
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.68E-01	2.29E+00	2.19E-01	1.92E-01	5.56E-01	2.58E-01	3.28E+00	3.25E-01	2.44E-01	8.92E-01

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Selenium	Hare					Grouse				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	6.30E-05	9.94E-05	6.72E-05	4.75E-05	4.31E-05	4.68E-05	7.39E-05	4.99E-05	3.53E-05	3.20E-05
Soil	4.49E-03	4.49E-03	5.34E-03	5.60E-03	6.39E-03	7.48E-03	7.48E-03	8.89E-03	9.31E-03	1.06E-02
Fish										
Forage	2.44E-03	6.91E-03	3.40E-03	1.79E-03	3.02E-03					
Browse	3.86E-03	2.51E-01	1.34E-02	3.18E-03	8.01E-03	5.70E-03	3.72E-01	1.98E-02	4.70E-03	1.18E-02
Berries						5.02E-04	4.36E-04	5.02E-04	5.02E-04	5.02E-04
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.09E-02	2.63E-01	2.22E-02	1.06E-02	1.75E-02	1.37E-02	3.80E-01	2.92E-02	1.45E-02	2.30E-02

Silver	Hare					Grouse				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	4.86E-05	6.81E-05	2.22E-05	9.66E-05	1.11E-04	3.61E-05	5.07E-05	1.65E-05	7.18E-05	8.21E-05
Soil	8.73E-03	8.73E-03	6.88E-02	5.08E-03	2.93E-02	1.45E-02	1.45E-02	1.15E-01	8.45E-03	4.87E-02
Fish										
Forage	1.22E-04	1.42E-02	1.53E-02	8.39E-04	1.51E-04					
Browse	2.37E-04	2.60E-02	1.63E-02	1.14E-03	2.44E-04	3.50E-04	3.85E-02	2.41E-02	1.68E-03	3.61E-04
Berries						2.51E-05	2.18E-05	1.65E-03	1.65E-03	2.51E-05
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	9.14E-03	4.90E-02	1.01E-01	7.15E-03	2.98E-02	1.49E-02	5.31E-02	1.40E-01	1.18E-02	4.92E-02

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Strontium	Hare					Grouse				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	9.66E-03	3.07E-02	2.52E-02	1.65E-02	1.91E-02	7.18E-03	2.28E-02	1.87E-02	1.23E-02	1.42E-02
Soil	2.21E-01	2.21E-01	2.32E-01	2.95E-01	1.69E-01	3.67E-01	3.67E-01	3.86E-01	4.91E-01	2.81E-01
Fish										
Forage	1.20E-01	1.73E-01	3.06E-01	2.92E-01	1.79E-01					
Browse	1.45E+00	2.79E+00	1.11E+00	6.39E-01	8.31E-01	2.14E+00	4.12E+00	1.64E+00	9.44E-01	1.23E+00
Berries						6.17E-03	6.94E-03	1.11E-02	1.11E-02	6.17E-03
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.80E+00	3.21E+00	1.67E+00	1.24E+00	1.20E+00	2.52E+00	4.52E+00	2.06E+00	1.46E+00	1.53E+00

Thallium	Hare					Grouse				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	3.35E-06	2.97E-06	4.62E-06	4.80E-06	3.06E-06	2.49E-06	2.20E-06	3.44E-06	3.57E-06	2.27E-06
Soil	2.64E-04	2.64E-04	2.72E-03	3.87E-04	2.72E-04	4.40E-04	4.40E-04	4.52E-03	6.44E-04	4.52E-04
Fish										
Forage	8.22E-04	3.30E-03	3.43E-03	6.00E-02	1.21E-03					
Browse	3.86E-04	5.59E-04	1.44E-03	1.86E-03	5.58E-04	5.70E-04	8.27E-04	2.13E-03	2.76E-03	8.25E-04
Berries						5.02E-05	5.02E-05	5.02E-05	5.02E-05	5.02E-05
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.48E-03	4.12E-03	7.59E-03	6.23E-02	2.04E-03	1.06E-03	1.32E-03	6.70E-03	3.45E-03	1.33E-03

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Uranium	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	1.20E-04	4.22E-04	3.06E-04	1.17E-04	1.01E-04	8.91E-05	3.13E-04	2.27E-04	8.70E-05	7.52E-05
Soil										
Fish										
Forage	4.89E-04	8.24E-04	6.76E-04	6.01E-04	6.04E-04					
Browse	7.71E-04	1.12E-03	1.71E-03	1.52E-03	8.46E-04	1.14E-03	1.65E-03	2.53E-03	2.24E-03	1.25E-03
Berries						1.00E-04	8.73E-05	1.00E-04	1.00E-04	1.00E-04
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.38E-03	2.36E-03	2.69E-03	2.24E-03	1.55E-03	1.33E-03	2.05E-03	2.86E-03	2.43E-03	1.43E-03

Vanadium	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	3.08E-04	2.35E-04	3.23E-04	2.02E-04	7.05E-05	2.29E-04	1.75E-04	2.40E-04	1.50E-04	5.24E-05
Soil	9.38E-02	9.38E-02	1.11E-01	7.78E-02	9.49E-02	1.56E-01	1.56E-01	1.85E-01	1.29E-01	1.58E-01
Fish										
Forage	6.11E-03	1.03E-02	1.98E-02	2.44E-02	7.56E-03					
Browse	9.64E-03	1.40E-02	3.39E-02	3.86E-02	1.06E-02	1.43E-02	2.07E-02	5.02E-02	5.70E-02	1.56E-02
Berries						1.25E-03	1.09E-03	1.26E-03	1.26E-03	1.25E-03
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.10E-01	1.18E-01	1.65E-01	1.41E-01	1.13E-01	1.72E-01	1.78E-01	2.36E-01	1.88E-01	1.75E-01

Table B.13 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Hare and Grouse

Zinc	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	6.68E-03	6.00E-02	8.97E-02	2.43E-03	8.24E-03	4.96E-03	4.46E-02	6.67E-02	1.81E-03	6.12E-03
Soil	4.81E-01	4.81E-01	9.88E+00	3.74E-01	4.34E+00	8.00E-01	8.00E-01	1.64E+01	6.22E-01	7.21E+00
Fish										
Forage	2.63E-01	2.11E+00	1.74E+00	1.12E+00	1.09E+00					
Browse	3.07E+00	3.71E+01	2.14E+01	7.90E+00	6.01E+00	4.53E+00	5.49E+01	3.17E+01	1.17E+01	8.89E+00
Berries						1.05E-01	9.90E-02	1.26E-01	1.26E-01	1.05E-01
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	3.82E+00	3.98E+01	3.31E+01	9.39E+00	1.15E+01	5.44E+00	5.58E+01	4.83E+01	1.24E+01	1.62E+01

Zirconium	**Hare**					**Grouse**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	8.19E-05	7.41E-05	7.80E-05	4.64E-05	5.17E-05	6.09E-05	5.51E-05	5.80E-05	3.45E-05	3.85E-05
Soil	1.14E-02	1.14E-02	1.08E-02	1.04E-02	8.36E-03	1.89E-02	1.89E-02	1.79E-02	1.73E-02	1.39E-02
Fish										
Forage	3.66E-02	6.18E-02	5.37E-02	3.66E-02	4.54E-02					
Browse	5.79E-02	8.39E-02	7.06E-02	5.79E-02	6.34E-02	8.55E-02	1.24E-01	1.04E-01	8.55E-02	9.37E-02
Berries						7.52E-03	6.54E-03	7.52E-03	7.52E-03	7.52E-03
Lichen										
Ducks										
Hare										
Caribou										
Moose										
Total	1.06E-01	1.57E-01	1.35E-01	1.05E-01	1.17E-01	1.12E-01	1.50E-01	1.30E-01	1.10E-01	1.15E-01

Note: GH – Galena Hill, MT – Mackeno Tailings, VT – Valley Tailings, SK – Silver King, SMQ – South McQuesten

Table B.14 Ecological Receptors Intakes by Pathway (mg/kg d) – Bear, Wolf, Marmot and Caribou

Antimony	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	4.72E-05	1.39E-05	4.31E-05	1.33E-04	8.16E-05	7.16E-05	2.48E-04	2.48E-05
Soil	2.84E-02	5.82E-03	2.98E-03	2.98E-03	7.08E-02	4.96E-03	3.32E-02	1.56E-02
Fish	9.87E-04							
Forage	5.33E-03		2.61E-03	5.20E-02	5.70E-02	2.99E-03	3.23E-03	4.87E-04
Browse								3.58E-04
Berries	1.68E-03							
Lichen								3.43E-02
Ducks								
Hare		2.13E-04						
Caribou	1.10E-04	3.22E-04						
Moose	4.83E-05	1.42E-04						
Total	3.66E-02	6.51E-03	5.63E-03	5.52E-02	1.28E-01	8.02E-03	3.67E-02	5.08E-02

Arsenic	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	4.56E-04	1.34E-04	9.96E-04	1.23E-03	4.48E-04	2.86E-04	7.44E-04	2.40E-04
Soil	2.32E-01	4.76E-02	3.37E-02	3.37E-02	5.67E-01	4.99E-02	1.79E-01	1.27E-01
Fish	1.13E-02							
Forage	1.92E-02		2.61E-03	2.25E-01	1.46E-01	4.29E-03	3.23E-03	1.75E-03
Browse								1.16E-03
Berries	5.31E-03							
Lichen								1.39E-01
Ducks								
Hare		2.38E-03						
Caribou	9.74E-04	2.85E-03						
Moose	3.87E-04	1.13E-03						
Total	2.70E-01	5.41E-02	3.73E-02	2.60E-01	7.14E-01	5.44E-02	1.83E-01	2.70E-01

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Barium	Bear	Wolf	Marmot					Caribou
Pathway	UKHM	UKHM	GH	MT	VT	SK	SMQ	UKHM
Water	3.82E-03	1.12E-03	5.11E-03	6.57E-03	5.00E-03	5.89E-03	6.92E-03	2.01E-03
Soil	5.69E-01	1.16E-01	1.04E+00	1.04E+00	1.09E+00	8.98E-01	3.85E-01	3.12E-01
Fish	2.85E-02							
Forage	5.89E-01		1.63E+00	3.61E+00	3.53E+00	5.18E+00	6.26E+00	5.37E-02
Browse								2.76E-02
Berries	1.39E-01							
Lichen								7.99E-02
Ducks								
Hare		1.16E-03						
Caribou	1.20E-04	3.51E-04						
Moose	1.97E-04	5.76E-04						
Total	1.33E+00	1.20E-01	2.67E+00	4.65E+00	4.63E+00	6.09E+00	6.66E+00	4.75E-01

Cadmium	Bear	Wolf	Marmot					Caribou
Pathway	UKHM	UKHM	GH	MT	VT	SK	SMQ	UKHM
Water	2.46E-04	7.23E-05	2.15E-05	2.20E-04	7.09E-04	4.22E-05	6.67E-05	1.29E-04
Soil	2.61E-02	5.35E-03	3.41E-03	3.41E-03	6.10E-02	1.79E-03	2.60E-02	1.43E-02
Fish	4.89E-03							
Forage	4.09E-03		5.21E-04	1.21E-01	3.95E-02	1.31E-03	6.45E-04	3.74E-04
Browse								5.09E-03
Berries	1.58E-03							
Lichen								1.12E-02
Ducks								
Hare		9.26E-04						
Caribou	2.92E-05	8.56E-05						
Moose	1.18E-04	3.45E-04						
Total	3.71E-02	6.78E-03	3.96E-03	1.24E-01	1.01E-01	3.15E-03	2.67E-02	3.11E-02

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Chromium	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	7.45E-05	2.19E-05	2.09E-04	1.50E-04	1.98E-04	1.71E-04	7.60E-05	3.92E-05
Soil	1.81E-02	3.71E-03	2.70E-02	2.70E-02	2.74E-02	2.24E-02	2.85E-02	9.94E-03
Fish	1.11E-02							
Forage	4.96E-03		2.61E-03	2.60E-02	3.23E-02	7.04E-02	1.76E-02	4.52E-04
Browse								4.95E-04
Berries	9.75E-04							
Lichen								6.56E-03
Ducks								
Hare		5.38E-04						
Caribou	1.74E-04	5.08E-04						
Moose	1.48E-04	4.34E-04						
Total	3.55E-02	5.22E-03	2.98E-02	5.32E-02	5.99E-02	9.29E-02	4.61E-02	1.75E-02

Cobalt	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	8.72E-05	2.56E-05	1.56E-04	1.17E-04	1.08E-04	4.03E-05	1.62E-04	4.59E-05
Soil	2.43E-02	4.99E-03	1.25E-02	1.25E-02	4.56E-02	2.51E-02	5.44E-02	1.33E-02
Fish	2.13E-03							
Forage	6.25E-04		2.61E-03	2.21E-02	3.75E-03	2.61E-03	3.23E-03	5.71E-05
Browse								3.92E-04
Berries	2.90E-04							
Lichen								1.27E-03
Ducks								
Hare		1.71E-04						
Caribou	1.17E-05	3.43E-05						
Moose	1.81E-05	5.30E-05						
Total	2.75E-02	5.27E-03	1.52E-02	3.47E-02	4.95E-02	2.77E-02	5.78E-02	1.51E-02

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Copper	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	2.36E-04	6.93E-05	6.57E-04	4.41E-04	5.08E-04	3.53E-04	4.40E-04	1.24E-04
Soil	5.73E-02	1.17E-02	4.99E-02	4.99E-02	1.05E-01	6.75E-02	6.26E-02	3.14E-02
Fish	1.46E-02							
Forage	4.76E-02		2.61E-03	4.77E-01	3.68E-01	2.75E-01	2.42E-01	4.34E-03
Browse								4.65E-03
Berries	2.70E-02							
Lichen								4.86E-02
Ducks								
Hare		4.61E-03						
Caribou	1.45E-03	4.24E-03						
Moose	2.05E-03	6.02E-03						
Total	1.50E-01	2.67E-02	5.32E-02	5.27E-01	4.73E-01	3.42E-01	3.05E-01	8.91E-02

Lead	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	6.41E-04	1.88E-04	2.57E-03	1.85E-03	1.17E-03	1.17E-03	7.96E-03	3.37E-04
Soil	1.54E+00	3.15E-01	9.44E-02	9.44E-02	4.14E+00	9.14E-02	5.69E-01	8.43E-01
Fish	5.62E-02							
Forage	2.06E-01		4.73E-03	1.02E+00	2.85E+00	4.41E-02	1.12E-02	1.88E-02
Browse								1.01E-02
Berries	5.75E-02							
Lichen								2.20E+00
Ducks								
Hare		6.61E-03						
Caribou	3.87E-03	1.13E-02						
Moose	1.03E-03	3.01E-03						
Total	1.86E+00	3.36E-01	1.02E-01	1.12E+00	6.99E+00	1.37E-01	5.88E-01	3.07E+00

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Manganese	Bear	Wolf	Marmot					Caribou
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	5.84E-02	1.72E-02	1.25E-02	8.12E-02	7.13E-02	6.12E-03	3.82E-02	3.07E-02
Soil	9.64E+00	1.98E+00	1.07E+00	1.07E+00	2.40E+01	5.38E+00	4.53E+00	5.28E+00
Fish	4.43E-01							
Forage	4.35E+00		1.88E+01	8.81E+01	2.23E+01	2.59E+01	2.48E+01	3.97E-01
Browse								1.83E-01
Berries	4.90E-01							
Lichen								2.56E+00
Ducks								
Hare		3.63E-02						
Caribou	9.16E-03	2.68E-02						
Moose	7.56E-03	2.22E-02						
Total	1.50E+01	2.08E+00	1.99E+01	8.93E+01	4.64E+01	3.13E+01	2.93E+01	8.46E+00

Mercury	Bear	Wolf	Marmot					Caribou
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	5.12E-06	1.50E-06	8.44E-07	8.44E-07	8.44E-06	8.44E-06	1.69E-06	2.69E-06
Soil	1.85E-04	3.79E-05	1.40E-04	1.40E-04	4.17E-04	1.14E-04	1.00E-04	1.01E-04
Fish	7.31E-03							
Forage	5.85E-05		2.61E-04	4.40E-04	3.58E-04	4.52E-04	3.23E-04	5.34E-06
Browse								4.26E-06
Berries	2.90E-05							
Lichen								1.94E-04
Ducks								
Hare		1.07E-05						
Caribou	5.55E-06	1.62E-05						
Moose	7.31E-06	2.14E-05						
Total	7.60E-03	8.78E-05	4.02E-04	5.81E-04	7.84E-04	5.74E-04	4.25E-04	3.07E-04

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Molybdenum	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	3.33E-05	9.80E-06	4.46E-05	5.23E-05	3.90E-05	6.00E-05	5.83E-05	1.75E-05
Soil	2.38E-03	4.89E-04	2.39E-03	2.39E-03	4.60E-03	3.06E-03	1.93E-03	1.31E-03
Fish	1.53E-03							
Forage	6.37E-04		2.61E-03	4.40E-03	3.48E-03	8.15E-03	5.01E-03	5.81E-05
Browse								3.31E-04
Berries	1.39E-03							
Lichen								5.02E-04
Ducks								
Hare		3.53E-05						
Caribou	4.00E-06	1.17E-05						
Moose	1.80E-05	5.29E-05						
Total	5.99E-03	5.98E-04	5.04E-03	6.84E-03	8.11E-03	1.13E-02	6.99E-03	2.22E-03

Nickel	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	5.47E-04	1.61E-04	2.79E-04	5.41E-04	4.39E-04	2.19E-04	9.04E-04	2.88E-04
Soil	5.45E-02	1.12E-02	3.65E-02	3.65E-02	5.37E-02	4.37E-02	2.04E-01	2.98E-02
Fish	1.16E-02							
Forage	7.58E-03		1.91E-02	1.69E-01	3.46E-02	8.78E-02	3.08E-02	6.92E-04
Browse								2.61E-03
Berries	5.45E-03							
Lichen								7.08E-03
Ducks								
Hare		9.25E-03						
Caribou	3.66E-04	1.07E-03						
Moose	6.29E-04	1.84E-03						
Total	8.07E-02	2.35E-02	5.59E-02	2.07E-01	8.87E-02	1.32E-01	2.35E-01	4.05E-02

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Selenium	Bear	Wolf	Marmot					Caribou
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	4.01E-05	1.18E-05	5.73E-05	9.04E-05	6.11E-05	4.32E-05	3.92E-05	2.11E-05
Soil	1.56E-03	3.20E-04	2.01E-03	2.01E-03	2.39E-03	2.51E-03	2.86E-03	8.56E-04
Fish	1.96E-02							
Forage	1.22E-03		5.21E-03	1.47E-02	7.25E-03	3.82E-03	6.45E-03	1.12E-04
Browse								2.66E-04
Berries	5.80E-04							
Lichen								8.29E-04
Ducks								
Hare		2.13E-02						
Caribou	3.76E-04	1.10E-03						
Moose	1.12E-03	3.29E-03						
Total	2.45E-02	2.60E-02	7.28E-03	1.68E-02	9.70E-03	6.37E-03	9.35E-03	2.08E-03

Silver	Bear	Wolf	Marmot					Caribou
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	1.81E-05	5.33E-06	4.42E-05	6.20E-05	2.02E-05	8.78E-05	1.00E-04	9.53E-06
Soil	1.27E-02	2.60E-03	3.91E-03	3.91E-03	3.08E-02	2.27E-03	1.31E-02	6.94E-03
Fish	3.65E-04							
Forage	3.00E-03		2.61E-04	3.04E-02	3.27E-02	1.79E-03	3.23E-04	2.74E-04
Browse								1.69E-04
Berries	1.17E-03							
Lichen								2.21E-02
Ducks								
Hare		1.71E-04						
Caribou	1.12E-04	3.27E-04						
Moose	6.50E-05	1.90E-04						
Total	1.74E-02	3.29E-03	4.21E-03	3.43E-02	6.35E-02	4.15E-03	1.35E-02	2.95E-02

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Strontium	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	1.51E-02	4.45E-03	8.78E-03	2.80E-02	2.29E-02	1.50E-02	1.74E-02	7.96E-03
Soil	6.45E-02	1.32E-02	9.87E-02	9.87E-02	1.04E-01	1.32E-01	7.57E-02	3.54E-02
Fish	1.46E-01							
Forage	1.01E-01		2.57E-01	3.69E-01	6.52E-01	6.24E-01	3.82E-01	9.18E-03
Browse								1.93E-02
Berries	7.78E-02							
Lichen								2.63E-02
Ducks								
Hare		3.38E-03						
Caribou	2.30E-04	6.74E-04						
Moose	1.77E-03	5.18E-03						
Total	4.06E-01	2.69E-02	3.64E-01	4.96E-01	7.79E-01	7.71E-01	4.75E-01	9.80E-02

Thallium	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	1.73E-06	5.07E-07	3.05E-06	2.70E-06	4.20E-06	4.36E-06	2.78E-06	9.07E-07
Soil	4.84E-04	9.91E-05	1.18E-04	1.18E-04	1.22E-03	1.73E-04	1.22E-04	2.65E-04
Fish	9.14E-05							
Forage	4.90E-03		1.76E-03	7.04E-03	7.32E-03	1.28E-01	2.57E-03	4.47E-04
Browse								2.49E-05
Berries	5.80E-05							
Lichen								2.30E-04
Ducks								
Hare		1.51E-03						
Caribou	5.24E-05	1.53E-04						
Moose	2.61E-05	7.65E-05						
Total	5.61E-03	1.84E-03	1.88E-03	7.16E-03	8.54E-03	1.28E-01	2.70E-03	9.68E-04

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Uranium	**Bear**	**Wolf**			**Marmot**			**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	1.39E-04	4.07E-05	1.09E-04	3.83E-04	2.78E-04	1.06E-04	9.20E-05	7.29E-05
Soil								
Fish	1.37E-04							
Forage	2.22E-04		1.04E-03	1.76E-03	1.44E-03	1.28E-03	1.29E-03	2.03E-05
Browse								2.56E-05
Berries	1.16E-04							
Lichen								2.04E-04
Ducks								
Hare		8.50E-07						
Caribou	2.28E-07	6.66E-07						
Moose	1.67E-05	4.90E-05						
Total	6.31E-04	9.12E-05	1.15E-03	2.14E-03	1.72E-03	1.39E-03	1.38E-03	3.23E-04

Vanadium	**Bear**	**Wolf**			**Marmot**			**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	9.19E-05	2.70E-05	2.80E-04	2.14E-04	2.94E-04	1.84E-04	6.41E-05	4.83E-05
Soil	2.79E-02	5.71E-03	4.20E-02	4.20E-02	4.97E-02	3.48E-02	4.25E-02	1.53E-02
Fish	1.98E-03							
Forage	6.14E-03		1.30E-02	2.20E-02	4.22E-02	5.21E-02	1.61E-02	5.60E-04
Browse								6.16E-04
Berries	1.45E-03							
Lichen								2.76E-03
Ducks								
Hare		3.34E-04						
Caribou	8.69E-05	2.55E-04						
Moose	1.64E-04	4.81E-04						
Total	3.78E-02	6.81E-03	5.53E-02	6.42E-02	9.22E-02	8.71E-02	5.87E-02	1.93E-02

Table B.14 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Bear, Wolf, Marmot and Caribou

Zinc	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	7.30E-02	2.14E-02	6.07E-03	5.46E-02	8.16E-02	2.21E-03	7.49E-03	3.84E-02
Soil	1.96E+00	4.01E-01	2.15E-01	2.15E-01	4.42E+00	1.67E-01	1.94E+00	1.07E+00
Fish	7.62E-01							
Forage	5.37E-01		5.61E-01	4.51E+00	3.72E+00	2.38E+00	2.33E+00	4.91E-02
Browse								3.13E-01
Berries	1.19E-01							
Lichen								8.56E-01
Ducks								
Hare		5.15E+00						
Caribou	6.72E-01	1.97E+00						
Moose	3.01E+00	8.80E+00						
Total	7.13E+00	1.63E+01	7.82E-01	4.78E+00	8.23E+00	2.55E+00	4.28E+00	2.33E+00

Zirconium	**Bear**	**Wolf**	**Marmot**					**Caribou**
Pathway	**UKHM**	**UKHM**	**GH**	**MT**	**VT**	**SK**	**SMQ**	**UKHM**
Water	3.66E-05	1.07E-05	7.45E-05	6.74E-05	7.10E-05	4.22E-05	4.70E-05	1.92E-05
Soil	3.55E-03	7.27E-04	5.09E-03	5.09E-03	4.83E-03	4.67E-03	3.74E-03	1.94E-03
Fish	1.89E-04							
Forage	1.70E-02		7.82E-02	1.32E-01	1.15E-01	7.82E-02	9.68E-02	1.55E-03
Browse								1.34E-03
Berries	8.70E-03							
Lichen								1.09E-02
Ducks								
Hare		1.53E-07						
Caribou	3.41E-08	9.98E-08						
Moose	5.69E-08	1.67E-07						
Total	2.94E-02	7.38E-04	8.34E-02	1.37E-01	1.20E-01	8.29E-02	1.01E-01	1.57E-02

Note: UKHM – United Keno Hill Mine (entire site), GH – Galena Hill, MT – Mackeno Tailings, VT – Valley Tailings, SK – Silver King, SMQ – South McQuesten

Table B.15 Ecological Receptors Intakes by Pathway (mg/kg d) – Fox and Sheep

Antimony	Fox					Sheep				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	4.34E-05	1.34E-04	8.23E-05	7.22E-05	2.50E-04	3.28E-05	1.02E-04	6.21E-05	5.45E-05	1.89E-04
Soil	9.46E-04	9.46E-04	2.25E-02	1.57E-03	1.05E-02	2.64E-03	2.64E-03	6.27E-02	4.39E-03	2.94E-02
Fish										
Forage						1.59E-03	3.17E-02	3.48E-02	1.82E-03	1.97E-03
Browse										
Berries	7.04E-05	6.12E-05	6.37E-04	6.37E-04	7.04E-05					
Lichen										
Ducks	8.25E-03	8.25E-03	8.25E-03	8.25E-03	8.25E-03					
Hare	4.62E-05	3.36E-04	1.03E-03	6.79E-05	3.66E-04					
Caribou										
Moose										
Total	9.35E-03	9.73E-03	3.24E-02	1.06E-02	1.95E-02	4.26E-03	3.45E-02	9.75E-02	6.27E-03	3.16E-02

Arsenic	Fox					Sheep				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	1.00E-03	1.24E-03	4.51E-04	2.89E-04	7.50E-04	7.59E-04	9.39E-04	3.41E-04	2.18E-04	5.66E-04
Soil	1.07E-02	1.07E-02	1.80E-01	1.58E-02	5.69E-02	2.99E-02	2.99E-02	5.03E-01	4.42E-02	1.59E-01
Fish										
Forage						1.59E-03	1.37E-01	8.89E-02	2.62E-03	1.97E-03
Browse										
Berries	7.04E-05	4.90E-04	2.03E-03	2.03E-03	7.04E-05					
Lichen										
Ducks	4.40E-01	4.40E-01	4.40E-01	4.40E-01	4.40E-01					
Hare	6.22E-04	3.60E-03	1.15E-02	9.19E-04	3.17E-03					
Caribou										
Moose										
Total	4.52E-01	4.56E-01	6.34E-01	4.59E-01	5.01E-01	3.22E-02	1.68E-01	5.92E-01	4.70E-02	1.61E-01

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Fox and Sheep

Barium	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	5.15E-03	6.62E-03	5.04E-03	5.93E-03	6.97E-03	3.89E-03	5.00E-03	3.81E-03	4.48E-03	5.27E-03
Soil	3.29E-01	3.29E-01	3.47E-01	2.85E-01	1.22E-01	9.18E-01	9.18E-01	9.70E-01	7.96E-01	3.41E-01
Fish										
Forage						9.95E-01	2.20E+00	2.15E+00	3.16E+00	3.82E+00
Browse										
Berries	1.45E-02	8.08E-03	1.08E-02	1.08E-02	1.45E-02					
Lichen										
Ducks	3.27E-03	3.27E-03	3.27E-03	3.27E-03	3.27E-03					
Hare	5.60E-03	4.87E-03	2.54E-03	2.76E-03	3.27E-03					
Caribou										
Moose										
Total	3.57E-01	3.52E-01	3.69E-01	3.08E-01	1.50E-01	1.92E+00	3.12E+00	3.13E+00	3.96E+00	4.16E+00

Cadmium	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	2.17E-05	2.21E-04	7.15E-04	4.25E-05	6.72E-05	1.64E-05	1.67E-04	5.40E-04	3.21E-05	5.08E-05
Soil	1.08E-03	1.08E-03	1.93E-02	5.69E-04	8.24E-03	3.02E-03	3.02E-03	5.40E-02	1.59E-03	2.30E-02
Fish										
Forage						3.18E-04	7.37E-02	2.41E-02	7.99E-04	3.93E-04
Browse										
Berries	5.77E-04	3.92E-04	4.98E-04	4.98E-04	5.77E-04					
Lichen										
Ducks	5.28E-02	5.28E-02	5.28E-02	5.28E-02	5.28E-02					
Hare	2.20E-04	4.47E-03	1.43E-03	2.75E-04	2.58E-04					
Caribou										
Moose										
Total	5.47E-02	5.89E-02	7.47E-02	5.41E-02	6.19E-02	3.36E-03	7.69E-02	7.86E-02	2.42E-03	2.35E-02

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Fox and Sheep

Chromium	Fox					Sheep				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	2.10E-04	1.51E-04	1.99E-04	1.72E-04	7.66E-05	1.59E-04	1.14E-04	1.50E-04	1.30E-04	5.79E-05
Soil	8.56E-03	8.56E-03	8.68E-03	7.09E-03	9.03E-03	2.39E-02	2.39E-02	2.43E-02	1.98E-02	2.52E-02
Fish										
Forage						1.59E-03	1.59E-02	1.97E-02	4.29E-02	1.07E-02
Browse										
Berries	2.82E-04	1.22E-04	2.26E-04	2.26E-04	2.82E-04					
Lichen										
Ducks	3.93E-03	3.93E-03	3.93E-03	3.93E-03	3.93E-03					
Hare	1.38E-03	1.85E-03	2.60E-03	2.23E-03	1.75E-03					
Caribou										
Moose										
Total	1.44E-02	1.46E-02	1.56E-02	1.36E-02	1.51E-02	2.57E-02	3.99E-02	4.41E-02	6.29E-02	3.60E-02

Cobalt	Fox					Sheep				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	1.57E-04	1.17E-04	1.09E-04	4.06E-05	1.63E-04	1.19E-04	8.87E-05	8.23E-05	3.07E-05	1.23E-04
Soil	3.96E-03	3.96E-03	1.45E-02	7.96E-03	1.73E-02	1.11E-02	1.11E-02	4.04E-02	2.22E-02	4.82E-02
Fish										
Forage						1.59E-03	1.35E-02	2.29E-03	1.59E-03	1.97E-03
Browse										
Berries	7.04E-05	6.12E-05	7.05E-05	7.05E-05	7.04E-05					
Lichen										
Ducks	9.85E-03	9.85E-03	9.85E-03	9.85E-03	9.85E-03					
Hare	9.65E-05	8.25E-04	1.92E-04	1.07E-04	2.52E-04					
Caribou										
Moose										
Total	1.41E-02	1.48E-02	2.47E-02	1.80E-02	2.76E-02	1.28E-02	2.46E-02	4.28E-02	2.38E-02	5.03E-02

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Fox and Sheep

Copper	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	6.62E-04	4.44E-04	5.12E-04	3.56E-04	4.43E-04	5.00E-04	3.36E-04	3.87E-04	2.69E-04	3.35E-04
Soil	1.58E-02	1.58E-02	3.32E-02	2.14E-02	1.98E-02	4.42E-02	4.42E-02	9.29E-02	5.98E-02	5.55E-02
Fish										
Forage						1.59E-03	2.91E-01	2.24E-01	1.67E-01	1.47E-01
Browse										
Berries	7.11E-03	6.25E-03	7.87E-03	7.87E-03	7.11E-03					
Lichen										
Ducks	9.34E-03	9.34E-03	9.34E-03	9.34E-03	9.34E-03					
Hare	5.50E-03	2.16E-02	2.21E-02	2.23E-02	1.25E-02					
Caribou										
Moose										
Total	3.84E-02	5.34E-02	7.31E-02	6.12E-02	4.92E-02	4.63E-02	3.35E-01	3.18E-01	2.27E-01	2.03E-01

Lead	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	2.59E-03	1.86E-03	1.17E-03	1.17E-03	8.03E-03	1.95E-03	1.41E-03	8.87E-04	8.87E-04	6.06E-03
Soil	2.99E-02	2.99E-02	1.31E+00	2.90E-02	1.80E-01	8.36E-02	8.36E-02	3.67E+00	8.10E-02	5.04E-01
Fish										
Forage						2.88E-03	6.24E-01	1.73E+00	2.69E-02	6.84E-03
Browse										
Berries	7.04E-05	1.22E-03	6.94E-02	6.94E-02	7.04E-05					
Lichen										
Ducks	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01					
Hare	6.08E-04	4.04E-03	3.19E-02	6.90E-04	3.54E-03					
Caribou										
Moose										
Total	1.80E-01	1.84E-01	1.56E+00	2.47E-01	3.39E-01	8.84E-02	7.09E-01	5.41E+00	1.09E-01	5.17E-01

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Fox and Sheep

Manganese	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	1.26E-02	8.18E-02	7.18E-02	6.17E-03	3.85E-02	9.51E-03	6.18E-02	5.43E-02	4.66E-03	2.91E-02
Soil	3.39E-01	3.39E-01	7.60E+00	1.71E+00	1.44E+00	9.46E-01	9.46E-01	2.12E+01	4.77E+00	4.01E+00
Fish										
Forage						1.14E+01	5.37E+01	1.36E+01	1.58E+01	1.51E+01
Browse										
Berries	1.94E-01	7.41E-02	1.18E-01	1.18E-01	1.94E-01					
Lichen										
Ducks	1.47E-02	1.47E-02	1.47E-02	1.47E-02	1.47E-02					
Hare	5.94E-02	1.75E-01	1.68E-01	7.49E-02	9.77E-02					
Caribou										
Moose										
Total	6.20E-01	6.85E-01	7.97E+00	1.92E+00	1.78E+00	1.24E+01	5.47E+01	3.49E+01	2.06E+01	1.91E+01

Mercury	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	8.51E-07	8.51E-07	8.51E-06	8.51E-06	1.70E-06	6.43E-07	6.43E-07	6.43E-06	6.43E-06	1.29E-06
Soil	4.45E-05	4.45E-05	1.32E-04	3.61E-05	3.17E-05	1.24E-04	1.24E-04	3.70E-04	1.01E-04	8.86E-05
Fish										
Forage						1.59E-04	2.68E-04	2.18E-04	2.75E-04	1.97E-04
Browse										
Berries	7.04E-06	6.12E-06	7.05E-06	7.05E-06	7.04E-06					
Lichen										
Ducks	1.17E-05	1.17E-05	1.17E-05	1.17E-05	1.17E-05					
Hare	2.46E-05	3.13E-05	5.18E-05	2.61E-05	2.30E-05					
Caribou										
Moose										
Total	8.88E-05	9.45E-05	2.11E-04	8.95E-05	7.51E-05	2.84E-04	3.93E-04	5.94E-04	3.83E-04	2.87E-04

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Fox and Sheep

Molybdenum	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	4.50E-05	5.27E-05	3.93E-05	6.05E-05	5.88E-05	3.40E-05	3.98E-05	2.97E-05	4.57E-05	4.44E-05
Soil	7.59E-04	7.59E-04	1.46E-03	9.71E-04	6.11E-04	2.12E-03	2.12E-03	4.07E-03	2.71E-03	1.71E-03
Fish										
Forage						1.59E-03	2.68E-03	2.12E-03	4.97E-03	3.05E-03
Browse										
Berries	5.17E-04	6.12E-05	3.85E-04	3.85E-04	5.17E-04					
Lichen										
Ducks	1.79E-04	1.79E-04	1.79E-04	1.79E-04	1.79E-04					
Hare	3.93E-05	1.60E-04	1.70E-04	1.32E-04	6.33E-05					
Caribou										
Moose										
Total	1.54E-03	1.21E-03	2.23E-03	1.73E-03	1.43E-03	3.74E-03	4.84E-03	6.22E-03	7.73E-03	4.80E-03

Nickel	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	2.81E-04	5.46E-04	4.43E-04	2.20E-04	9.11E-04	2.12E-04	4.12E-04	3.34E-04	1.67E-04	6.88E-04
Soil	1.16E-02	1.16E-02	1.70E-02	1.38E-02	6.45E-02	3.23E-02	3.23E-02	4.75E-02	3.87E-02	1.80E-01
Fish										
Forage						1.17E-02	1.03E-01	2.11E-02	5.35E-02	1.88E-02
Browse										
Berries	2.07E-03	3.67E-04	7.35E-04	7.35E-04	2.07E-03					
Lichen										
Ducks	6.67E-03	6.67E-03	6.67E-03	6.67E-03	6.67E-03					
Hare	3.28E-03	4.46E-02	4.29E-03	3.75E-03	1.09E-02					
Caribou										
Moose										
Total	2.39E-02	6.38E-02	2.91E-02	2.52E-02	8.50E-02	4.42E-02	1.36E-01	6.90E-02	9.24E-02	2.00E-01

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Fox and Sheep

Selenium	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	5.78E-05	9.11E-05	6.16E-05	4.35E-05	3.95E-05	4.36E-05	6.88E-05	4.65E-05	3.29E-05	2.98E-05
Soil	6.38E-04	6.38E-04	7.58E-04	7.94E-04	9.07E-04	1.78E-03	1.78E-03	2.12E-03	2.22E-03	2.53E-03
Fish										
Forage						3.18E-03	8.99E-03	4.42E-03	2.33E-03	3.93E-03
Browse										
Berries	1.41E-04	1.22E-04	1.41E-04	1.41E-04	1.41E-04					
Lichen										
Ducks	7.43E-02	7.43E-02	7.43E-02	7.43E-02	7.43E-02					
Hare	4.24E-03	1.03E-01	8.66E-03	4.15E-03	6.82E-03					
Caribou										
Moose										
Total	7.94E-02	1.78E-01	8.39E-02	7.94E-02	8.22E-02	5.00E-03	1.08E-02	6.58E-03	4.58E-03	6.49E-03

Silver	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	4.46E-05	6.25E-05	2.04E-05	8.85E-05	1.01E-04	3.37E-05	4.72E-05	1.54E-05	6.69E-05	7.65E-05
Soil	1.24E-03	1.24E-03	9.77E-03	7.20E-04	4.16E-03	3.46E-03	3.46E-03	2.73E-02	2.01E-03	1.16E-02
Fish										
Forage						1.59E-04	1.85E-02	1.99E-02	1.09E-03	1.97E-04
Browse										
Berries	7.04E-06	6.12E-06	4.63E-04	4.63E-04	7.04E-06					
Lichen										
Ducks	2.30E-03	2.30E-03	2.30E-03	2.30E-03	2.30E-03					
Hare	7.50E-05	4.02E-04	8.24E-04	5.86E-05	2.44E-04					
Caribou										
Moose										
Total	3.66E-03	4.01E-03	1.34E-02	3.63E-03	6.80E-03	3.66E-03	2.20E-02	4.72E-02	3.17E-03	1.19E-02

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Fox and Sheep

Strontium	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	8.85E-03	2.82E-02	2.31E-02	1.51E-02	1.75E-02	6.69E-03	2.13E-02	1.74E-02	1.14E-02	1.32E-02
Soil	3.13E-02	3.13E-02	3.29E-02	4.19E-02	2.40E-02	8.75E-02	8.75E-02	9.20E-02	1.17E-01	6.70E-02
Fish										
Forage						1.56E-01	2.25E-01	3.98E-01	3.81E-01	2.33E-01
Browse										
Berries	1.73E-03	1.95E-03	3.11E-03	3.11E-03	1.73E-03					
Lichen										
Ducks	1.46E-02	1.46E-02	1.46E-02	1.46E-02	1.46E-02					
Hare	9.12E-03	1.63E-02	8.51E-03	6.31E-03	6.09E-03					
Caribou										
Moose										
Total	6.56E-02	9.24E-02	8.22E-02	8.11E-02	6.40E-02	2.51E-01	3.34E-01	5.07E-01	5.09E-01	3.13E-01

Thallium	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	3.07E-06	2.72E-06	4.24E-06	4.40E-06	2.80E-06	2.32E-06	2.05E-06	3.20E-06	3.32E-06	2.12E-06
Soil	3.75E-05	3.75E-05	3.85E-04	5.49E-05	3.85E-05	1.05E-04	1.05E-04	1.08E-03	1.53E-04	1.08E-04
Fish										
Forage						1.07E-03	4.29E-03	4.46E-03	7.81E-02	1.57E-03
Browse										
Berries	1.41E-05	1.41E-05	1.41E-05	1.41E-05	1.41E-05					
Lichen										
Ducks	1.60E-02	1.60E-02	1.60E-02	1.60E-02	1.60E-02					
Hare	1.73E-04	4.83E-04	8.89E-04	7.30E-03	2.39E-04					
Caribou										
Moose										
Total	1.63E-02	1.66E-02	1.73E-02	2.34E-02	1.63E-02	1.18E-03	4.40E-03	5.54E-03	7.82E-02	1.68E-03

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Fox and Sheep

Uranium	Fox					Sheep				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	1.10E-04	3.86E-04	2.80E-04	1.07E-04	9.28E-05	8.29E-05	2.92E-04	2.12E-04	8.10E-05	7.01E-05
Soil										
Fish										
Forage						6.36E-04	1.07E-03	8.79E-04	7.82E-04	7.86E-04
Browse										
Berries	2.82E-05	2.45E-05	2.82E-05	2.82E-05	2.82E-05					
Lichen										
Ducks	5.13E-03	5.13E-03	5.13E-03	5.13E-03	5.13E-03					
Hare	2.10E-06	3.60E-06	4.10E-06	3.41E-06	2.36E-06					
Caribou										
Moose										
Total	5.27E-03	5.55E-03	5.45E-03	5.27E-03	5.26E-03	7.19E-04	1.36E-03	1.09E-03	8.63E-04	8.56E-04

Vanadium	Fox					Sheep				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	2.83E-04	2.15E-04	2.96E-04	1.86E-04	6.46E-05	2.13E-04	1.63E-04	2.24E-04	1.40E-04	4.88E-05
Soil	1.33E-02	1.33E-02	1.58E-02	1.10E-02	1.35E-02	3.72E-02	3.72E-02	4.40E-02	3.08E-02	3.76E-02
Fish										
Forage						7.95E-03	1.34E-02	2.57E-02	3.18E-02	9.83E-03
Browse										
Berries	3.52E-04	3.06E-04	3.53E-04	3.53E-04	3.52E-04					
Lichen										
Ducks	1.88E-02	1.88E-02	1.88E-02	1.88E-02	1.88E-02					
Hare	1.07E-03	1.16E-03	1.61E-03	1.38E-03	1.10E-03					
Caribou										
Moose										
Total	3.38E-02	3.38E-02	3.68E-02	3.17E-02	3.38E-02	4.53E-02	5.07E-02	7.00E-02	6.28E-02	4.75E-02

Table B.15 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) - Fox and Sheep

Zinc	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	6.12E-03	5.50E-02	8.22E-02	2.23E-03	7.55E-03	4.62E-03	4.15E-02	6.21E-02	1.68E-03	5.70E-03
Soil	6.82E-02	6.82E-02	1.40E+00	5.31E-02	6.15E-01	1.91E-01	1.91E-01	3.92E+00	1.48E-01	1.72E+00
Fish										
Forage						3.42E-01	2.75E+00	2.27E+00	1.45E+00	1.42E+00
Browse										
Berries	2.94E-02	2.78E-02	3.53E-02	3.53E-02	2.94E-02					
Lichen										
Ducks	1.42E+00	1.42E+00	1.42E+00	1.42E+00	1.42E+00					
Hare	2.39E+00	2.49E+01	2.07E+01	5.87E+00	7.16E+00					
Caribou										
Moose										
Total	3.91E+00	2.64E+01	2.37E+01	7.38E+00	9.23E+00	5.37E-01	2.98E+00	6.25E+00	1.60E+00	3.15E+00

Zirconium	**Fox**					**Sheep**				
Pathway	**GH**	**MT**	**VT**	**SK**	**SMQ**	**GH**	**MT**	**VT**	**SK**	**SMQ**
Water	7.51E-05	6.79E-05	7.15E-05	4.26E-05	4.74E-05	5.67E-05	5.13E-05	5.40E-05	3.21E-05	3.58E-05
Soil	1.62E-03	1.62E-03	1.53E-03	1.48E-03	1.19E-03	4.51E-03	4.51E-03	4.28E-03	4.13E-03	3.32E-03
Fish										
Forage						4.77E-02	8.04E-02	6.99E-02	4.77E-02	5.90E-02
Browse										
Berries	2.11E-03	1.84E-03	2.11E-03	2.11E-03	2.11E-03					
Lichen										
Ducks	3.93E-08	3.93E-08	3.93E-08	3.93E-08	3.93E-08					
Hare	4.97E-07	7.37E-07	6.34E-07	4.92E-07	5.49E-07					
Caribou										
Moose										
Total	3.80E-03	3.52E-03	3.71E-03	3.63E-03	3.35E-03	5.23E-02	8.50E-02	7.43E-02	5.18E-02	6.24E-02

Note: GH – Galena Hill, MT – Mackeno Tailings, VT – Valley Tailings, SK – Silver King, SMQ – South McQuesten

Table B.16 Ecological Receptors Intakes by Pathway (mg/kg d) –Mink, Ducks, Beaver and Moose

Antimony	Mink				Mallard	Merganser	Scaup	Beaver				Moose
Pathway	GH	MT	SK	SMQ	MT	MT	MT	GH	MT	SK	SMQ	UKHM
Water	5.05E-05	1.56E-04	8.40E-05	2.91E-04	4.54E-05	4.66E-05	5.01E-05	3.61E-05	1.12E-04	6.01E-05	2.08E-04	4.26E-05
Sediment	2.16E-02	2.13E-01	8.40E-05	1.89E-01	7.63E-02	5.82E-02	3.31E-01	1.91E-02	1.89E-01	7.44E-05	1.67E-01	7.69E-03
Fish	3.45E-03	1.38E-02	4.49E-03	3.53E-02		1.39E-02						
Browse								1.15E-03	2.40E-02	1.15E-03	1.25E-03	4.69E-03
Aquatic Veg	5.61E-03	1.74E-02	9.33E-03	3.23E-02	4.57E-02		2.11E-02	3.98E-02	1.23E-01	6.62E-02	2.30E-01	2.94E-03
Benthic Invertebrates	1.01E-04	3.13E-04	1.68E-04	5.82E-04	1.36E-03		2.19E-03					
Ducks	6.24E-03	6.24E-03	6.24E-03	6.24E-03								
Hare	3.43E-05	2.49E-04	5.04E-05	2.72E-04								
Total	3.70E-02	2.52E-01	2.04E-02	2.64E-01	1.23E-01	7.22E-02	3.55E-01	6.01E-02	3.37E-01	6.75E-02	3.98E-01	1.54E-02

Arsenic	Mink				Mallard	Merganser	Scaup	Beaver				Moose
Pathway	GH	MT	SK	SMQ	MT	MT	MT	GH	MT	SK	SMQ	UKHM
Water	1.17E-03	1.45E-03	3.36E-04	8.72E-04	4.19E-04	4.31E-04	4.63E-04	8.36E-04	1.03E-03	2.40E-04	6.24E-04	4.12E-04
Sediment	7.72E-01	3.85E+00	2.31E-04	5.61E-01	1.38E+00	1.05E+00	5.98E+00	6.84E-01	3.41E+00	2.05E-04	4.98E-01	5.24E-02
Fish	1.02E-01	2.50E-01	1.85E-02	1.26E-01		2.52E-01						
Browse								1.15E-03	1.66E-01	2.33E-03	1.37E-03	1.52E-02
Aquatic Veg	2.60E-02	3.21E-02	7.46E-03	1.94E-02	8.45E-02		3.90E-02	1.84E-01	2.28E-01	5.29E-02	1.38E-01	5.69E-03
Benthic Invertebrates	3.97E-01	4.91E-01	1.14E-01	2.97E-01	2.13E+00		3.44E+00					
Ducks	3.33E-01	3.33E-01	3.33E-01	3.33E-01								
Hare	4.62E-04	2.67E-03	6.83E-04	2.35E-03								
Total	1.63E+00	4.96E+00	4.74E-01	1.34E+00	3.60E+00	1.30E+00	9.46E+00	8.70E-01	3.81E+00	5.57E-02	6.37E-01	7.38E-02

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Barium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	5.99E-03	7.70E-03	6.90E-03	8.11E-03	2.23E-03	2.30E-03	2.47E-03	4.29E-03	5.51E-03	4.94E-03	5.80E-03	3.45E-03
Sediment	3.35E-01	6.53E-01	9.20E-03	6.84E-01	2.34E-01	1.78E-01	1.01E+00	2.97E-01	5.79E-01	8.15E-03	6.06E-01	5.10E-02
Fish	4.05E-01	2.70E-01	9.07E-02	3.78E-01		2.72E-01						
Browse								4.25E+00	2.91E+00	3.58E-01	1.30E+00	3.63E-01
Aquatic Veg	3.33E-01	4.28E-01	3.83E-01	4.50E-01	1.13E+00		5.20E-01	2.36E+00	3.04E+00	2.72E+00	3.20E+00	1.19E-01
Benthic Invertebrates	2.40E-01	3.08E-01	2.76E-01	3.24E-01	1.34E+00		2.16E+00					
Ducks	2.47E-03	2.47E-03	2.47E-03	2.47E-03								
Hare	4.16E-03	3.62E-03	2.05E-03	2.43E-03								
Total	1.33E+00	1.67E+00	7.71E-01	1.85E+00	2.70E+00	4.53E-01	3.69E+00	6.91E+00	6.53E+00	3.09E+00	5.10E+00	5.36E-01

Cadmium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	2.52E-05	2.57E-04	4.95E-05	7.82E-05	7.46E-05	7.67E-05	8.24E-05	1.80E-05	1.84E-04	3.54E-05	5.59E-05	2.22E-04
Sediment	4.47E-02	3.89E-01	4.73E-03	9.13E-02	1.39E-01	1.06E-01	6.04E-01	3.96E-02	3.45E-01	4.19E-03	8.09E-02	7.92E-03
Fish	3.19E-02	8.05E-02	1.20E-02	6.16E-02		8.13E-02						
Browse								5.97E-02	1.27E+00	7.77E-02	4.07E-02	6.67E-02
Aquatic Veg	2.13E-03	2.17E-02	4.18E-03	6.60E-03	5.72E-02		2.64E-02	1.51E-02	1.54E-01	2.97E-02	4.68E-02	1.17E-02
Benthic Invertebrates	5.04E-04	5.15E-03	9.90E-04	1.56E-03	2.24E-02		3.61E-02					
Ducks	3.99E-02	3.99E-02	3.99E-02	3.99E-02								
Hare	1.63E-04	3.32E-03	2.04E-04	1.91E-04								
Total	1.19E-01	5.40E-01	6.20E-02	2.01E-01	2.19E-01	1.88E-01	6.67E-01	1.14E-01	1.77E+00	1.12E-01	1.68E-01	8.65E-02

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Chromium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	2.45E-04	1.76E-04	2.00E-04	8.91E-05	5.11E-05	5.25E-05	5.64E-05	1.75E-04	1.26E-04	1.43E-04	6.38E-05	6.73E-05
Sediment	5.74E-02	4.09E-02	1.33E-04	3.28E-02	1.46E-02	1.12E-02	6.35E-02	5.08E-02	3.63E-02	1.18E-04	2.91E-02	3.74E-03
Fish	1.12E+00	7.54E-02	1.16E-02	1.81E-01		7.61E-02						
Browse								1.32E-03	8.01E-03	1.22E-02	5.59E-03	6.49E-03
Aquatic Veg	3.26E-06	2.35E-06	2.67E-06	1.19E-06	6.18E-06		2.86E-06	2.31E-05	1.67E-05	1.89E-05	8.43E-06	5.58E-07
Benthic Invertebrates	9.78E-04	7.05E-04	8.00E-04	3.57E-04	3.06E-03		4.94E-03					
Ducks	2.97E-03	2.97E-03	2.97E-03	2.97E-03								
Hare	1.02E-03	1.37E-03	1.65E-03	1.30E-03								
Total	1.18E+00	1.22E-01	1.73E-02	2.19E-01	1.78E-02	8.73E-02	6.85E-02	5.24E-02	4.44E-02	1.24E-02	3.48E-02	1.03E-02

Cobalt	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	1.83E-04	1.37E-04	4.72E-05	1.90E-04	3.96E-05	4.07E-05	4.38E-05	1.31E-04	9.78E-05	3.38E-05	1.36E-04	7.88E-05
Sediment	2.30E-02	1.24E-01	5.25E-03	3.78E-02	4.42E-02	3.37E-02	1.92E-01	2.04E-02	1.10E-01	4.65E-03	3.35E-02	4.33E-03
Fish	2.06E-02	1.07E-02	1.37E-02	1.12E-02		1.08E-02						
Browse								1.68E-02	2.70E-01	3.78E-03	1.61E-02	5.14E-03
Aquatic Veg	2.44E-02	1.82E-02	6.30E-03	2.53E-02	4.79E-02		2.21E-02	1.73E-01	1.29E-01	4.47E-02	1.80E-01	6.53E-03
Benthic Invertebrates	8.06E-04	6.01E-04	2.08E-04	8.36E-04	2.61E-03		4.21E-03					
Ducks	7.46E-03	7.46E-03	7.46E-03	7.46E-03								
Hare	7.16E-05	6.13E-04	7.94E-05	1.88E-04								
Total	7.66E-02	1.61E-01	3.31E-02	8.30E-02	9.48E-02	4.45E-02	2.18E-01	2.11E-01	5.09E-01	5.32E-02	2.30E-01	1.61E-02

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Copper	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	7.70E-04	5.17E-04	4.14E-04	5.16E-04	1.50E-04	1.54E-04	1.66E-04	5.51E-04	3.70E-04	2.96E-04	3.69E-04	2.13E-04
Sediment	8.86E-02	1.94E-01	9.20E-02	3.19E-01	6.94E-02	5.29E-02	3.01E-01	7.85E-02	1.72E-01	8.15E-02	2.83E-01	1.12E-02
Fish	1.47E-01	1.37E-01	7.50E-02	1.55E-01		1.38E-01						
Browse								2.56E-02	1.65E-01	2.10E-01	6.01E-02	6.09E-02
Aquatic Veg	8.56E-02	5.74E-02	4.60E-02	5.73E-02	1.51E-01		6.98E-02	6.07E-01	4.07E-01	3.26E-01	4.07E-01	1.47E-02
Benthic Invertebrates	6.47E-03	4.34E-03	3.48E-03	4.33E-03	1.89E-02		3.04E-02					
Ducks	7.07E-03	7.07E-03	7.07E-03	7.07E-03								
Hare	4.09E-03	1.60E-02	1.65E-02	9.26E-03								
Total	3.40E-01	4.17E-01	2.40E-01	5.53E-01	2.39E-01	1.92E-01	4.02E-01	7.12E-01	7.45E-01	6.18E-01	7.50E-01	8.71E-02

Lead	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	3.01E-03	2.17E-03	1.37E-03	9.34E-03	6.29E-04	6.46E-04	6.94E-04	2.15E-03	1.55E-03	9.78E-04	6.68E-03	5.79E-04
Sediment	8.98E-01	9.79E+00	8.20E-03	6.45E+00	3.50E+00	2.67E+00	1.52E+01	7.96E-01	8.68E+00	7.27E-03	5.72E+00	3.55E-01
Fish	7.06E-02	1.02E+00	6.31E-02	1.39E+00		1.03E+00						
Browse								3.91E-03	4.67E-01	1.56E-02	5.58E-03	1.33E-01
Aquatic Veg	6.02E-01	4.34E-01	2.73E-01	1.87E+00	1.14E+00		5.27E-01	4.27E+00	3.08E+00	1.94E+00	1.33E+01	7.20E-02
Benthic Invertebrates	1.32E-02	9.54E-03	6.01E-03	4.11E-02	4.14E-02		6.68E-02					
Ducks	1.11E-01	1.11E-01	1.11E-01	1.11E-01								
Hare	4.52E-04	3.00E-03	5.13E-04	2.63E-03								
Total	1.70E+00	1.14E+01	4.64E-01	9.87E+00	4.69E+00	3.70E+00	1.58E+01	5.07E+00	1.22E+01	1.96E+00	1.90E+01	5.60E-01

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Manganese	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	1.47E-02	9.51E-02	7.18E-03	4.47E-02	2.76E-02	2.83E-02	3.05E-02	1.05E-02	6.81E-02	5.14E-03	3.20E-02	5.27E-02
Sediment	3.28E+00	1.06E+02	1.60E-01	2.45E+01	3.79E+01	2.89E+01	1.64E+02	2.91E+00	9.38E+01	1.41E-01	2.17E+01	1.74E+00
Fish	1.51E+00	7.05E+00	4.37E-01	7.39E+00		7.12E+00						
Browse								8.41E+00	1.85E+01	4.63E+00	1.18E+01	2.40E+00
Aquatic Veg	2.77E-01	1.80E+00	1.36E-01	8.45E-01	4.73E+00		2.18E+00	1.96E+00	1.28E+01	9.62E-01	6.00E+00	6.19E-01
Benthic Invertebrates	2.20E-04	1.43E-03	1.08E-04	6.71E-04	6.20E-03		1.00E-02					
Ducks	1.11E-02	1.11E-02	1.11E-02	1.11E-02								
Hare	4.41E-02	1.30E-01	5.56E-02	7.25E-02								
Total	5.14E+00	1.15E+02	8.06E-01	3.29E+01	4.26E+01	3.60E+01	1.66E+02	1.33E+01	1.25E+02	5.74E+00	3.96E+01	4.81E+00

Mercury	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	9.90E-07	9.90E-07	9.90E-06	1.98E-06	2.87E-07	2.95E-07	3.17E-07	7.08E-07	7.08E-07	7.08E-06	1.42E-06	4.62E-06
Sediment	5.37E-04	2.51E-04	2.20E-04	1.02E-03	8.97E-05	6.84E-05	3.89E-04	4.76E-04	2.22E-04	1.95E-04	9.07E-04	4.95E-05
Fish	8.72E-03	8.72E-03	8.72E-02	1.74E-02		8.81E-03						
Browse								1.15E-04	1.66E-04	1.15E-04	1.25E-04	5.59E-05
Aquatic Veg	5.83E-05	5.83E-05	5.83E-04	1.17E-04	1.53E-04		7.09E-05	4.14E-04	4.14E-04	4.14E-03	8.27E-04	1.69E-04
Benthic Invertebrates	1.49E-04	1.49E-04	1.49E-03	2.97E-04	6.45E-04		1.04E-03					
Ducks	8.87E-06	8.87E-06	8.87E-06	8.87E-06								
Hare	1.83E-05	2.32E-05	1.94E-05	1.70E-05								
Total	9.49E-03	9.21E-03	8.96E-02	1.89E-02	8.88E-04	8.88E-03	1.50E-03	1.00E-03	8.03E-04	4.45E-03	1.86E-03	2.79E-04

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Molybdenum	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	5.23E-05	6.13E-05	7.04E-05	6.84E-05	1.78E-05	1.83E-05	1.96E-05	3.74E-05	4.38E-05	5.04E-05	4.89E-05	3.01E-05
Sediment	7.26E-03	5.50E-03	1.41E-03	3.38E-03	1.97E-03	1.50E-03	8.54E-03	6.43E-03	4.88E-03	1.25E-03	3.00E-03	4.30E-04
Fish	1.47E-01	9.90E-03	1.93E-04	2.39E-02		9.99E-03						
Browse								2.04E-03	2.00E-02	1.37E-02	5.65E-03	4.35E-03
Aquatic Veg	5.81E-03	6.81E-03	7.82E-03	7.60E-03	1.79E-02		8.28E-03	4.13E-02	4.83E-02	5.55E-02	5.39E-02	2.08E-03
Benthic Invertebrates	4.71E-06	5.52E-06	6.34E-06	6.15E-06	2.40E-05		3.86E-05					
Ducks	1.35E-04	1.35E-04	1.35E-04	1.35E-04								
Hare	2.92E-05	1.19E-04	9.79E-05	4.70E-05								
Total	1.61E-01	2.25E-02	9.73E-03	3.51E-02	1.99E-02	1.15E-02	1.69E-02	4.98E-02	7.32E-02	7.05E-02	6.26E-02	6.89E-03

Nickel	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	3.27E-04	6.35E-04	2.56E-04	1.06E-03	1.84E-04	1.89E-04	2.03E-04	2.34E-04	4.54E-04	1.83E-04	7.58E-04	4.94E-04
Sediment	6.84E-02	2.38E-01	1.08E-02	1.27E-01	8.50E-02	6.48E-02	3.69E-01	6.06E-02	2.11E-01	9.60E-03	1.12E-01	1.15E-02
Fish	7.56E-01	4.92E-02	7.78E-03	9.27E-02		4.97E-02						
Browse								4.61E-02	1.26E+00	3.16E-02	5.10E-02	3.43E-02
Aquatic Veg	1.82E-03	3.53E-03	1.42E-03	5.89E-03	9.27E-03		4.29E-03	1.29E-02	2.50E-02	1.01E-02	4.18E-02	1.71E-03
Benthic Invertebrates	6.53E-03	1.27E-02	5.13E-03	2.12E-02	5.51E-02		8.89E-02					
Ducks	5.04E-03	5.04E-03	5.04E-03	5.04E-03								
Hare	2.44E-03	3.32E-02	2.79E-03	8.06E-03								
Total	8.41E-01	3.42E-01	3.32E-02	2.60E-01	1.50E-01	1.15E-01	4.62E-01	1.20E-01	1.50E+00	5.15E-02	2.06E-01	4.80E-02

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Selenium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	6.72E-05	1.06E-04	5.06E-05	4.59E-05	3.07E-05	3.16E-05	3.39E-05	4.81E-05	7.58E-05	3.62E-05	3.28E-05	3.62E-05
Sediment	5.50E-03	6.82E-03	2.47E-06	1.05E-02	2.44E-03	1.86E-03	1.06E-02	4.88E-03	6.05E-03	2.19E-06	9.30E-03	6.05E-04
Fish	3.69E-01	1.53E-01	8.65E-02	1.27E-01		1.55E-01						
Browse								2.30E-03	1.50E-01	1.89E-03	4.77E-03	3.48E-03
Aquatic Veg	4.70E-04	7.42E-04	3.54E-04	3.21E-04	1.95E-03		9.01E-04	3.34E-03	5.26E-03	2.51E-03	2.28E-03	1.57E-04
Benthic Invertebrates	7.66E-03	1.21E-02	5.77E-03	5.23E-03	5.24E-02		8.46E-02					
Ducks	5.62E-02	5.62E-02	5.62E-02	5.62E-02								
Hare	3.15E-03	7.62E-02	3.08E-03	5.07E-03								
Total	4.42E-01	3.06E-01	1.52E-01	2.04E-01	5.69E-02	1.57E-01	9.61E-02	1.06E-02	1.61E-01	4.44E-03	1.64E-02	4.28E-03

Silver	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	5.18E-05	7.27E-05	1.03E-04	1.18E-04	2.11E-05	2.17E-05	2.33E-05	3.71E-05	5.20E-05	7.37E-05	8.43E-05	1.64E-05
Sediment	2.20E-02	2.77E-02	2.52E-03	2.81E-02	9.92E-03	7.56E-03	4.30E-02	1.95E-02	2.46E-02	2.23E-03	2.49E-02	9.35E-03
Fish	2.57E-03	3.86E-03	1.64E-02	2.00E-03		3.90E-03						
Browse								1.41E-04	1.55E-02	6.76E-04	1.45E-04	2.22E-03
Aquatic Veg	1.15E-03	1.61E-03	2.29E-03	2.62E-03	4.25E-03		1.96E-03	8.17E-03	1.15E-02	1.62E-02	1.86E-02	2.26E-04
Benthic Invertebrates	7.98E-03	1.12E-02	1.59E-02	1.81E-02	4.86E-02		7.84E-02					
Ducks	1.74E-03	1.74E-03	1.74E-03	1.74E-03								
Hare	5.57E-05	2.99E-04	4.36E-05	1.82E-04								
Total	3.56E-02	4.65E-02	3.89E-02	5.29E-02	6.28E-02	1.15E-02	1.23E-01	2.79E-02	5.16E-02	1.92E-02	4.37E-02	1.18E-02

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Strontium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	1.03E-02	3.28E-02	1.76E-02	2.04E-02	9.50E-03	9.76E-03	1.05E-02	7.37E-03	2.34E-02	1.26E-02	1.46E-02	1.37E-02
Sediment	3.72E-02	7.48E-02	3.92E-01	6.82E-02	2.68E-02	2.04E-02	1.16E-01	3.30E-02	6.63E-02	3.47E-01	6.05E-02	7.13E-03
Fish	1.24E+00	5.91E-01	5.26E-01	1.54E+00		5.96E-01						
Browse								8.60E-01	1.66E+00	3.80E-01	4.95E-01	2.53E-01
Aquatic Veg	2.97E-01	9.47E-01	5.09E-01	5.89E-01	2.49E+00		1.15E+00	2.11E+00	6.72E+00	3.61E+00	4.18E+00	2.45E-01
Benthic Invertebrates	5.56E-01	1.77E+00	9.52E-01	1.10E+00	7.69E+00		1.24E+01					
Ducks	1.11E-02	1.11E-02	1.11E-02	1.11E-02								
Hare	6.77E-03	1.21E-02	4.69E-03	4.52E-03								
Total	2.16E+00	3.44E+00	2.41E+00	3.33E+00	1.02E+01	6.27E-01	1.37E+01	3.01E+00	8.47E+00	4.35E+00	4.75E+00	5.19E-01

Thallium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	3.57E-06	3.16E-06	5.11E-06	3.26E-06	9.17E-07	9.42E-07	1.01E-06	2.56E-06	2.26E-06	3.66E-06	2.33E-06	1.56E-06
Sediment	1.32E-04	5.28E-04	1.70E-04	9.26E-04	1.89E-04	1.44E-04	8.20E-04	1.17E-04	4.68E-04	1.51E-04	8.21E-04	4.07E-06
Fish	7.15E-04	7.15E-04	6.65E-03	2.72E-03		7.22E-04						
Browse								2.30E-04	3.33E-04	1.11E-03	3.32E-04	3.27E-04
Aquatic Veg	3.97E-07	3.51E-07	5.68E-07	3.62E-07	9.24E-07		4.27E-07	2.82E-06	2.49E-06	4.03E-06	2.57E-06	1.08E-07
Benthic Invertebrates	3.57E-03	3.16E-03	5.11E-03	3.26E-03	1.37E-02		2.21E-02					
Ducks	1.21E-02	1.21E-02	1.21E-02	1.21E-02								
Hare	1.28E-04	3.59E-04	5.42E-03	1.77E-04								
Total	1.67E-02	1.69E-02	2.95E-02	1.92E-02	1.39E-02	8.67E-04	2.30E-02	3.52E-04	8.06E-04	1.27E-03	1.16E-03	3.32E-04

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Uranium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	1.28E-04	4.49E-04	1.25E-04	1.08E-04	1.30E-04	1.34E-04	1.44E-04	9.14E-05	3.22E-04	8.93E-05	7.72E-05	1.25E-04
Sediment	2.00E-03	1.67E-02	1.39E-04	3.30E-03	5.98E-03	4.56E-03	2.60E-02	1.77E-03	1.48E-02	1.23E-04	2.93E-03	1.39E-02
Fish	1.46E-03	3.45E-03	1.55E-04	5.69E-04		3.48E-03						
Browse								4.59E-04	6.66E-04	9.03E-04	5.03E-04	3.36E-04
Aquatic Veg	3.26E-03	1.15E-02	3.19E-03	2.76E-03	3.02E-02		1.40E-02	2.32E-02	8.15E-02	2.26E-02	1.96E-02	1.99E-03
Benthic Invertebrates	4.34E-03	1.53E-02	4.24E-03	3.67E-03	6.64E-02		1.07E-01					
Ducks	3.88E-03	3.88E-03	3.88E-03	3.88E-03								
Hare	1.56E-06	2.67E-06	2.53E-06	1.76E-06								
Total	1.51E-02	5.13E-02	1.17E-02	1.43E-02	1.03E-01	8.17E-03	1.47E-01	2.55E-02	9.73E-02	2.37E-02	2.31E-02	1.64E-02

Vanadium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	3.29E-04	2.50E-04	2.16E-04	7.52E-05	7.26E-05	7.46E-05	8.02E-05	2.35E-04	1.79E-04	1.54E-04	5.38E-05	8.29E-05
Sediment	5.48E-02	7.04E-02	2.40E-04	5.42E-02	2.52E-02	1.92E-02	1.09E-01	4.86E-02	6.24E-02	2.13E-04	4.80E-02	5.46E-03
Fish	3.55E-02	2.89E-02	3.02E-02	2.30E-02		2.92E-02						
Browse								5.74E-03	8.32E-03	2.30E-02	6.29E-03	8.07E-03
Aquatic Veg	7.30E-02	5.57E-02	4.80E-02	1.67E-02	1.46E-01		6.77E-02	5.18E-01	3.95E-01	3.40E-01	1.19E-01	1.15E-02
Benthic Invertebrates	2.50E-02	1.90E-02	1.64E-02	5.71E-03	8.27E-02		1.33E-01					
Ducks	1.42E-02	1.42E-02	1.42E-02	1.42E-02								
Hare	7.97E-04	8.58E-04	1.02E-03	8.20E-04								
Total	2.04E-01	1.89E-01	1.10E-01	1.15E-01	2.54E-01	4.84E-02	3.10E-01	5.73E-01	4.66E-01	3.64E-01	1.73E-01	2.51E-02

Table B.16 (Cont'd) Ecological Receptors Intakes by Pathway (mg/kg d) – Mink, Ducks, Beaver and Moose

Zinc	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	7.12E-03	6.40E-02	2.59E-03	8.78E-03	1.85E-02	1.91E-02	2.05E-02	5.09E-03	4.58E-02	1.86E-03	6.28E-03	6.59E-02
Sediment	2.38E+00	3.34E+01	2.88E-02	4.09E+00	1.20E+01	9.12E+00	5.19E+01	2.11E+00	2.96E+01	2.55E-02	3.63E+00	4.98E-01
Fish	5.33E+00	8.11E+00	9.36E-01	8.39E+00		8.19E+00						
Browse								1.82E+00	2.21E+01	4.70E+00	3.58E+00	4.10E+00
Aquatic Veg	4.35E-01	3.91E+00	1.59E-01	5.37E-01	1.03E+01		4.75E+00	3.09E+00	2.77E+01	1.12E+00	3.81E+00	2.50E+00
Benthic Invertebrates	1.31E-01	1.18E+00	4.77E-02	1.62E-01	5.11E+00		8.24E+00					
Ducks	1.07E+00	1.07E+00	1.07E+00	1.07E+00								
Hare	1.77E+00	1.85E+01	4.36E+00	5.32E+00								
Total	1.11E+01	6.62E+01	6.61E+00	1.96E+01	2.74E+01	1.73E+01	6.49E+01	7.03E+00	7.95E+01	5.85E+00	1.10E+01	7.17E+00

Zirconium	**Mink**				**Mallard**	**Merganser**	**Scaup**	**Beaver**				**Moose**
Pathway	**GH**	**MT**	**SK**	**SMQ**	**MT**	**MT**	**MT**	**GH**	**MT**	**SK**	**SMQ**	**UKHM**
Water	8.73E-05	7.90E-05	4.95E-05	5.51E-05	2.29E-05	2.35E-05	2.53E-05	6.25E-05	5.65E-05	3.54E-05	3.95E-05	3.30E-05
Sediment	5.77E-03	5.50E-03	1.10E-03	5.55E-03	1.97E-03	1.50E-03	8.54E-03	5.11E-03	4.88E-03	9.75E-04	4.92E-03	5.34E-04
Fish	2.78E-03	2.51E-03	1.57E-03	1.75E-03		2.53E-03						
Browse								3.44E-02	4.99E-02	3.44E-02	3.77E-02	1.75E-02
Aquatic Veg	2.91E-08	2.63E-08	1.65E-08	1.84E-08	6.93E-08		3.20E-08	2.07E-07	1.87E-07	1.17E-07	1.30E-07	6.84E-09
Benthic Invertebrates	8.73E-04	7.90E-04	4.95E-04	5.51E-04	3.43E-03		5.53E-03					
Ducks	2.98E-08	2.98E-08	2.98E-08	2.98E-08								
Hare	3.69E-07	5.47E-07	3.65E-07	4.08E-07								
Total	9.51E-03	8.88E-03	3.22E-03	7.91E-03	5.42E-03	4.06E-03	1.41E-02	3.96E-02	5.48E-02	3.54E-02	4.27E-02	1.81E-02

Note: UKHM – United Keno Hill Mine (entire site), GH – Galena Hill, MT – Mackeno Tailings, VT – Valley Tailings, SK – Silver King, SMQ – South McQuesten

APPENDIX C

ECOLOGICAL CHARACTERISTICS OF TERRESTRIAL ECOLOGICAL RECEPTORS

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APPENDIX C: ECOLOGICAL CHARACTERISTICS OF TERRESTRIAL ECOLOGICAL RECEPTORS

C.1 GENERAL OVERVIEW

This appendix presents the summary table of ecological characteristics of the terrestrial ecological receptors considered in this assessment. The ecological receptors considered in this assessment included the following: bear, beaver, Dall sheep, fox, hoary marmot, mink, moose, snowshoe hare, spruce grouse, wolf, woodland caribou, and waterfowl (mallard, merganser, scaup). Information on water and food ingestion rates were obtained from literature sources, as is the typical approach for ecological risk assessments. The soil and sediment ingestion rates were obtained from Beyer *et al.* (1994). The dietary characteristics and time spent in the study area are entered into the pathways model so that estimates of exposure can be obtained.

Table C-1 Bear Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	9,500	U.S. EPA 1993
Food ingestion rate [a]	g(wet wt.)/d	14,900	U.S. EPA 1993
Fraction of food that is berries	-	0.4	Holcroft and Herrero 1991
Fraction of food that is forage	-	0.33	Holcroft and Herrero 1991
Fraction of food that is fish	-	0.15	Canadian Wildlife Service 2008
Fraction of food that is moose	-	0.05	Canadian Wildlife Service 2008
Fraction of food that is caribou		0.05	Canadian Wildlife Service 2008
Soil ingestion rate	g(dry wt.)/d	393	Calculated from Beyer *et al.* 1994
Body weight	kg	225	Dewey and Kronk 2007
Fraction of time in study area	-	0.1	Assumed

Notes:
a Based on the allometric equation provided in U.S. EPA (1993) and a body weight of 225 kg for a black bear.

Table C-2 Beaver Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	1,700	Calculated from U.S. EPA 1993
Food ingestion rate [a]	g(wet wt.)/d	3,747	Calculated from U.S. EPA 1993
Fraction of food that is browse	-	0.49	Assumed based on information in CWS 2005, NatureServe 2007
Fraction of food that is aquatic vegetation	-	0.5	
Sediment ingestion rate	g(dry wt.)/d	46.88	Calculated from Beyer *et al.* 1994
Body weight	kg	24	CWS 2005, NatureServe 2007
Fraction of time in study area	-	1	Assumed

Notes:
a Based on allometric equation provided in U.S. EPA (1993) and the body weight of 24 kg (CWS 2005, NatureServe 2007).

Table C-3 Dall Sheep Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	4,500	Calculated from U.S. EPA 1993
Food ingestion rate [a]	g(wet wt.)/d	7,530	Calculated from U.S. EPA 1993
Fraction of food that is forage	-	0.985	Based on information in NatureServe 2007
Soil ingestion rate	g(dry wt.)/d	113	Calculated from Beyer *et al.* 1994
Body weight	kg	70	U.S. EPA 1993
Fraction of time in study area	-	1	Assumed

Notes:
a Based on allometric equation provided in U.S. EPA (1993) and the body weight of 70 kg for (U.S. EPA 1993).

Table C-4 Fox Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	383	Calculated from U.S. EPA 1993
Food ingestion rate [a]	g(wet wt.)/d	310	Calculated from U.S. EPA 1993
Fraction of food that is berry	-	0.14	Assumed based on information in U.S. EPA, 1993
Fraction of food that is browse	-	0.07	
Fraction of food that is forage	-	0.07	
Fraction of food that is small mammals	-	0.43	
Fraction of food that is ducks	-	0.422	
Soil ingestion rate	g(dry wt.)/d	2.6	Calculated from Beyer *et al.* 1994
Body weight	kg	4.5	U.S. EPA, 1993
Fraction of time in study area	-		Assumed

Notes:
a Based on the allometric equation provided in U.S. EPA (1993) and a body weight of 4.5 kg for a fox (U.S. EPA 1993).

Table C-5 Hoary Marmot Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	380	Calculated from U.S. EPA 1993
Food ingestion rate [a]	g(wet wt.)/d	790	Calculated from U.S. EPA 1993
Fraction of food that is forage	-	0.99	Assumed based on information in Gunderman and Olson 2009, NatureServe 2007
Soil ingestion rate [b]	g(dry wt.)/d	8.2	Calculated from Beyer *et al.* 1994
Body weight	kg	4.5	Gunderman and Olson 2009, NatureServe 2007
Fraction of time in study area	-	1	Assumed

Notes:
a Based on the allometric equation provided in U.S. EPA (1993) and a body weight of 4.5 kg (Gunderman and Olson 2009, NatureServe 2007).

Table C-6 Mink Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	99	Calculated from U.S. EPA 1993
Food ingestion rate [a]	g(wet wt.)/d	220	Calculated from U.S. EPA 1993
Fraction of food that is aquatic vegetation	-	0.05	Based on information from U.S. EPA 1993, TAG 2001, Schlimme 2003
Fraction of food that is benthic invertebrates	-	0.09	
Fraction of food that is fish	-	0.65	
Fraction of food that is small mammals	-	0.1	
Fraction of food that is ducks	-	0.1	
Sediment ingestion rate	g(dry wt.)/d	2.2	Calculated from Beyer *et al.* 1994
Body weight	kg	1	U.S. EPA 1193
Fraction of time in study area	-	1	Assumed

Notes:
a Based on the allometric equation provided in U.S. EPA (1993) and an average body weight of 1 kg (U.S. EPA 1993).

Table C-7 Moose Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	31,300	Calculated from U.S. EPA 1993
Food ingestion rate [b]	g(wet wt.)/d	23,000	Canadian Wildlife Service 1997
Fraction of food that is browse	-	0.9	Belovsky *et al.* 1973
Fraction of food that is aquatic vegetation	-	0.09	Belovsky *et al.* 1973
Sediment ingestion rate	g(dry wt.)/d	138	Calculated from Beyer *et al.* 1994
Body weight	kg	600	Canadian Wildlife Service 1997
Fraction of time in study area	-	1	Assumed

Notes:
a Based on the allometric equation provided in U.S. EPA 1993 and a body weight of 600 kg for moose (CWS 1997).
b The Canadian Wildlife Service (CWS) report that moose eat 15 – 20 kg/d twigs and shrubs in the winter and 20 – 30 kg/d forage consisting of twigs, leaves, shrubs, upland and water plants in the summer.

Table C-8 Snowshoe Hare Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	130	Calculated from U.S. EPA 1993
Food ingestion rate [b]	g(wet wt.)/d	300	Pease *et al.* 1979
Fraction of food that is forage [c]	-	0.38	U.S. EPA 1993
Fraction of food that is browse [c]	-	0.6	U.S. EPA 1993
Soil ingestion rate	g(dry wt.)/d	5.7	Calculated from Beyer *et al.* 1994
Body weight	kg	1.4	U.S. EPA 1993
Fraction of time in study area	-	1	Assumed

Notes:
a Based on allometric equation for water intake from U.S. EPA (1993) and using the body weight of a hare of 1.4 kg and water intake of Eastern Cottontail Rabbit from U.S. EPA (1993).
b This value is consistent with the value obtained for an allometric equation for herbivores given in U.S. EPA (1993).
c Based on the dietary composition of Eastern Cottontail Rabbit from U.S. EPA (1993).

Table C-9 Spruce Grouse Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	42.8	Calculated from U.S. EPA 1993
Food ingestion rate [a]	g(wet wt.)/d	142	Calculated from U.S. EPA 1993
Fraction of food that is browse [b]	-	0.83	U.S. EPA 1993
Fraction of food that is berries [b]	-	0.15	U.S. EPA 1993
Soil ingestion rate	g(dry wt.)/d	4.2	Calculated from Beyer *et al*. 1994
Body weight	kg	0.62	NatureServe 2007, Cornell 2003
Fraction of time in study area	-	1	Assumed

Notes:

a Based on allometric equation provided in U.S. EPA (1993) and a body weight of 620 g for a spruce grouse.

c Based on breakdown of food intake by a quail in U.S. EPA (1993).

Table C-10 Wolf Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	2,920	U.S. EPA 1993
Food ingestion rate [b]	g(wet wt.)/d	5,500	Fuller and Keith 1980
Fraction of food that is hare [c]	-	0.19	U.S. EPA 1993
Fraction of food that is moose [c]	-	0.40	U.S. EPA 1993
Fraction of food that is caribou [c]	-	0.40	U.S. EPA 1993
Soil ingestion rate	g(dry wt.)/d	46.2	Calculated from Beyer *et al.* 1994
Body weight	kg	43	Schmidt and Gilbert 1978
Fraction of time in study area	-	0.25	Assumed

Notes:

a Based on the allometric equation provided in U.S. EPA (1993) and a body weight of 43 kg for a gray wolf (Schmidt and Gilbert 1978).

b Based on study of Fuller and Keith (1980) which estimate that gray wolf in northeastern Alberta eat 5.5 kg/d.

c Based on the intake of foxes from U.S. EPA (1993) and wolves from the Canadian Wildlife Service (1993b).

Table C-11 Woodland Caribou Receptor Characteristics

Parameter Description	Units	Value	Reference
Water ingestion rate [a]	g/d	8200	Calculated from U.S. EPA 1993
Food ingestion rate [a]	g(wet wt.)/d	6457	Calculated from U.S. EPA 1993
Fraction of food that is forage	-	0.11	Based on CWS 2005, NatureServe 2007, Shefferly and Joly 2000
Fraction of food that is browse	-	0.11	
Fraction of food that is lichen	-	0.75	
Soil ingestion rate	g(dry wt.)/d	194	Calculated from Beyer *et al*. 1994
Body weight	kg	135	ADF&G 1999
Fraction of time in study area	-	0.5	Assumed

Notes:

a Based on the allometric equation provided in U.S. EPA (1993) and a body weight of 135 kg for a woodland caribou.

Table C-12 Waterfowl Receptor Characteristics

Parameter Description	Units	Value	Reference
Food ingestion rate[a] mallard common merganser scaup	g(wet wt.)/d	250 290 255	CCME 1998
Fraction of time spent in study area [b] mallard common merganser scaup	-	0.50	U.S. EPA 1993
Fraction of food that is fish mallard common merganser scaup	-	0.0 0.996 0.0	U.S. EPA 1993 Andress and Parker 1995 U.S. EPA 1993
Fraction of food that is benthic invertebrates mallard common merganser scaup	-	0.74 0.0 0.89	U.S. EPA 1993
Fraction of food that is aquatic vegetation mallard common merganser scaup	-	0.25 0.0 0.09	U.S. EPA 1993 U.S. EPA 1993
Sediment ingestion rate mallard common merganser scaup	g(dry wt.)/d	1.7 1.2 5.6	Calculated from Beyer *et al.* 1994
Water ingestion rate [c] mallard common merganser scaup	g/d	62 59 52	Calculated from U.S. EPA 1993
Body weight mallard common merganser scaup	kg	1.08 1 0.82	U.S. EPA 1993 Cornell 2003 U.S. EPA 1993

Notes:
a Taken from CCME (1998) along with body weights of 1082 g for a mallard, 820 g for a scaup and 1000 g for common merganser.
b Based on information that scaup and mallards migrate and spend 4 – 8 months away from this area.
c Based on the allometric equation published in U.S. EPA (1993).

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APPENDIX D

SAMPLE CALCULATIONS

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APPENDIX D: SAMPLE CALCULATIONS

This appendix provides sample intake calculations for human and ecological receptors at the historic Keno Hill Mine site.

D.1 ECOLOGICAL RECEPTORS

Table D.1 Sample Intake Calculations for Selected Ecological Receptors at the Historic Keno Hill Mine Site for Arsenic

SAMPLE CALCULATION **Arsenic - Mackeno Tailings (MT)**

Notes:
fw indicates fresh weight
dw indicates dry weight

Parameter	Units	Symbol	Value	Reference or Equation
Transfer Factors				
Water-to-benthic transfer factor	L/kg (FW)	TFben	1700	U.S. EPA 1979, COGEMA 1997
Water-to-aq veg transfer factor	L/kg (FW)	TFaqveg	200	NTIS 1988, CSA1987
Feed-to-mallard transfer factor	d/kg (FW)	TFmallard	1.59	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987b
Feed-to-scaup transfer factor	d/kg (FW)	TFscaup	1.95	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987b
Feed-to-merganser transfer factor	d/kg (FW)	TFmerganser	1.68	IAEA 1994, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987b
Feed-to-hare transfer factor	d/kg (FW)	TFhare	0.19	IAEA 1994, NCRP 1996, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987c
Feed-to-caribou transfer factor	d/kg (FW)	TFcaribou	0.01	IAEA 1994, NCRP 1996, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987c
Feed-to-moose transfer factor	d/kg (FW)	TFmoose	0.00	IAEA 1994, NCRP 1996, Baes *et al.* 1984, U.S. EPA 1998, CSA 1987c
Measured Concentrations				
Water concentration - Entire Site (UKHM)	mg/L	WatcUKHM	0.00789	95% UCLM of measured water conc at United Keno Hill Mine (entire site)
Water concentration - Mackeno Tailings (MT)	mg/L	WatcMT	0.0146	95% UCLM of measured water conc at Mackeno Tailings
Sediment concentration - Entire Site (UKHM)	mg/kg dw	SedcUKHM	228	95% UCLM of measured sediment conc at United Keno Hill Mine (entire site)
Sediment concentration - Mackeno Tailings (MT)	mg/kg dw	SedcMT	1750	Maximum measured sediment conc at Mackeno Tailings
Soil concentration - Entire Site (UKHM)	mg/kg dw	SoilcUKHM	177.2	95% UCLM of measured soil concentration at United Keno Hill Mine (entire site)
Soil concentration - Mackeno Tailings (MT)	mg/kg dw	SoilcMT	18.5	95% UCLM of measured soil concentration at Mackeno Tailings
Forage concentration - Entire Site (UKHM)	mg/kg (FW)	ForagecUKHM	0.67	95% UCLM of measured forage concentration at United Keno Hill Mine (entire site)

Forage concentration - Mackeno Tailings (MT)	mg/kg (FW)	ForagecMT	1.30	Maximum measured forage concentration at Mackeno Tailings
Browse concentration - Entire Site (UKHM)	mg/kg (FW)	BrowsecUKHM	0.442	95% UCLM of measured browse concentration at United Keno Hill Mine (entire site)
Browse concentration - Mackeno Tailings (MT)	mg/kg (FW)	BrowsecMT	2.16	Maximum measured browse concentration at Mackeno Tailings
Berries concentration - Entire Site (UKHM)	mg/kg (FW)	BerriescUKHM	0.15	95% UCLM of measured berries concentration at United Keno Hill Mine (entire site)
Berries concentration - Mackeno Tailings (MT)	mg/kg (FW)	BerriescMT	0.051	Maximum measured berries concentration at Mackeno Tailings
Lichen concentration - Entire Site (UKHM)	mg/kg (FW)	LichencUKHM	7.77	95% UCLM of measured lichen concentration at United Keno Hill Mine (entire site)
Fish concentration - Entire Site (UKHM)	mg/kg (FW)	FishcUKHM	0.83	95% UCLM of measured fish concentration at United Keno Hill Mine (entire site)
Fish concentration - Mackeno Tailings (MT)	mg/kg (FW)	FishcMT	1.75	95% UCLM of measured fish concentration at Mackeno Tailings
Benthic Invertebrate concentration - Entire Site (UKHM)	mg/kg (FW)	BencUKHM	13.4	=WatcUKHM*TFBen
Benthic Invertebrate concentration - Mackeno Tailings (MT)	mg/kg (FW)	BencMT	24.8	=WatcMT*TFBen
Aquatic Vegetation concentration - Entire Site (UKHM)	mg/kg (FW)	AqvegcUKHM	1.58	=WatcUKHM*TFaqveg
Aquatic Vegetation concentration - Mackeno Tailings (MT)	mg/kg (FW)	AqvegcMT	2.92	=WatcMT*TFaqveg
Duck concentration - Mackeno Tailings (MT)	mg/kg (FW)	DuckcMT	1.5E+01	=MAX(Itotma*TFmallard*BWma, Itotsc*TFScaup*BWsc, Itotme*TFmerganser*BWme)
Hare concentration - Mackeno Tailings (MT)	mg/kg (FW)	HarecMT	1.2E-01	=Itoth*TFhare*BWh
Caribou concentration - Entire Site (UKHM)	mg/kg (FW)	CariboucUKHM	2.2E-01	=Itotc*TFcaribou*BWc
Moose concentration - Entire Site (UKHM)	mg/kg (FW)	MoosecUKHM	8.9E-02	=Itotmo*TFmoose*BWmo
Hare - Mackeno Tailings (MT)				
Body weight	kg	BWh	1.4	U.S. EPA, 1993
Water ingestion rate	g/d	Qwath	130	U.S. EPA, 1993
Soil ingestion rate	g DW/d	Qsdwh	5.7	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwh	300	Pease *et al.* (1979)
Fraction that is forage	-	Ffh	0.38	U.S. EPA, 1993
Fraction that is browse	-	Fbwh	0.6	U.S. EPA, 1993
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLoh	1.26	Schroeder and Mitchener (1971)
Fraction of time at site	-	Floch	1	assumed to be at Mackeno Tailings for the entire year
Intake of COC from water by body weight	mg/kg-d	Iwh	1.36E-03	=Qwath*WatcMT*Floch/BWh/1000 grams per liter
Intake of COC from soil by body weight	mg/kg-d	Ish	7.53E-02	=Qsdwh*SoilcMT*Floch/BWh/1000 grams per kilogram
Intake of COC from forage by body weight	mg/kg-d	Ifh	1.06E-01	=Qffwh*Ffh*ForagecMT*Floch/BWh/1000 grams per kilogram
Intake of COC from browse by body weight	mg/kg-d	Ibwh	2.78E-01	=Qffwh*Fbwh*BrowsecMT*Floch/BWh/1000 grams per kilogram
Total intake	mg/kg-d	Itoth	4.61E-01	=Iwh+Ish+Ifh+Ibwh
Screening Index - LOAEL	-	SIh	0.37	=Itoth/ToxLoh

Sheep - Mackeno Tailings (MT)				
Body weight	kg	BWs	70	CWS (1997)
Water ingestion rate	g/d	Qwats	4500	U.S. EPA, 1993
Soil ingestion rate	g DW/d	Qsdws	113	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffws	7530	U.S. EPA, 1993
Fraction that is forage	-	Ffs	0.985	CWS (1997)
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLos	1.26	USFWS 1964(a)
Fraction of time at site	-	Flocs	1	assumed to be at Mackeno Tailings for the entire year
Intake of COC from water by body weight	mg/kg-d	Iws	9.39E-04	=Qwats*WatcMT*Flocs/BWs/1000 grams per liter
Intake of COC from soil by body weight	mg/kg-d	Iss	2.99E-02	=Qsdws*SoilcMT*Flocs/BWs/1000 grams per kilogram
Intake of COC from forage by body weight	mg/kg-d	Ifs	1.37E-01	=Qffws*Ffs*ForagecMT*Flocs/BWs/1000 grams per kilogram
Total intake	mg/kg-d	Itots	1.68E-01	=Iws+Iss+Ifs
Screening Index - LOAEL	-	SIs	0.13	=Itots/ToxLos
Mallard - Mackeno Tailings (MT)				
Body weight	kg	BWma	1.08	U.S. EPA, 1993
Water ingestion rate	g/d	Qwatma	62	U.S. EPA, 1993
Sediment ingestion rate	g DW/d	Qsedwma	1.7	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwma	250	U.S. EPA, 1993
Fraction that is aquatic vegetation	-	Favma	0.25	U.S. EPA, 1993
Fraction that is benthic invertebrates	-	Fbima	0.743	U.S. EPA, 1993
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLoma	12.84	USFWS 1964(a)
Fraction of time at site	-	Flocma	0.5	assumed to be at Mackeno Tailings for six months
Intake of COC from water by body weight	mg/kg-d	Iwma	4.19E-04	=Qwatma*WatcMT*Flocma/BWma/1000 grams per liter
Intake of COC from sediment by body weight	mg/kg-d	Isma	1.38E+00	=Qsedwma*SedcMT*Flocma/BWma/1000 grams per kilogram
Intake of COC from aquatic vegetation by body weight	mg/kg-d	Iavma	8.45E-02	=Qffwma*Favma*AqvegcMT*Flocma/BWma/1000 grams per kilogram
Intake of COC from benthic by body weight	mg/kg-d	Ibima	2.13E+00	=Qffwma*Fbima*BencMT*Flocma/BWma/1000 grams per kilogram
Total intake	mg/kg-d	Itotma	3.60E+00	=Iwma+Isma+Iavma+Ibima
Screening Index - LOAEL	-	SIma	0.28	=Itotma/ToxLoma
Scaup - Mackeno Tailings (MT)				
Body weight	kg	BWsc	0.82	U.S. EPA, 1993
Water ingestion rate	g/d	Qwatsc	52	U.S. EPA, 1993
Sediment ingestion rate	g DW/d	Qsedwsc	5.6	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwsc	255	U.S. EPA, 1993
Fraction that is aquatic vegetation	-	Favsc	0.086	U.S. EPA, 1993
Fraction that is benthic invertebrates	-	Fbisc	0.892	U.S. EPA, 1993
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLosc	12.84	USFWS 1964(a)
Fraction of time at site	-	Flocsc	0.5	assumed to be at Mackeno Tailings for six months

Intake of COC from water by body weight	mg/kg-d	Iwsc	4.63E-04	=Qwatsc*WatcMT*Flocsc/BWsc/1000 grams per liter
Intake of COC from sediment by body weight	mg/kg-d	Issc	5.98E+00	=Qsedwsc*SedcMT*Flocsc/BWsc/1000 grams per kilogram
Intake of COC from aquatic vegetation by body weight	mg/kg-d	Iavsc	3.90E-02	=Qffwsc*Favsc*AqvegcMT*Flocsc/BWsc/1000 grams per kilogram
Intake of COC from benthic by body weight	mg/kg-d	Ibisc	3.44E+00	=Qffwsc*Fbisc*BencMT*Flocsc/BWsc/1000 grams per kilogram
Total intake	mg/kg-d	Itotsc	9.46E+00	=Iwsc+Issc+Iavsc+Ibisc
Screening Index - LOAEL	-	SIsc	**0.74**	=Itotsc/ToxLosc
Merganser - Mackeno Tailings (MT)				
Body weight	kg	BWme	1.0	Cornell 2003
Water ingestion rate	g/d	Qwatme	59	U.S. EPA, 1993
Sediment ingestion rate	g DW/d	Qsedwme	1.2	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwme	290	CCME 1998
Fraction that is fish	-	Ffime	0.996	Becker & Fraser 2006, NatureServe 2008, Cornell 2003
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLome	12.84	USFWS 1964(a)
Fraction of time at site	-	Flocme	0.5	assumed to be at Mackeno Tailings for six months
Intake of COC from water by body weight	mg/kg-d	Iwme	4.31E-04	=Qwatme*WatcMT*Flocme/BWme/1000 grams per liter
Intake of COC from sediment by body weight	mg/kg-d	Isme	1.05E+00	=Qsedwme*SedcMT*Flocme/BWme/1000 grams per kilogram
Intake of COC from fish by body weight	mg/kg-d	Ifime	2.52E-01	=Qffwme*Ffime*FishcMT*Flocme/BWme/1000 grams per kilogram
Total intake	mg/kg-d	Itotme	1.30E+00	=Iwme+Isme+Ifime
Screening Index - LOAEL	-	SIme	0.10	=Itotme/ToxLome
Mink - Mackeno Tailings (MT)				
Body weight	kg	BWmi	1	U.S. EPA, 1993
Water ingestion rate	g/d	Qwatmi	99	U.S. EPA, 1993
Sediment ingestion rate	g DW/d	Qsedwmi	2.2	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwmi	220	U.S. EPA, 1993
Fraction that is aquatic vegetation	-	Favmi	0.05	U.S. EPA, 1993
Fraction that is benthic invertebrates	-	Fbimi	0.09	U.S. EPA, 1993
Fraction that is fish	-	Ffimi	0.65	U.S. EPA, 1993
Fraction that is ducks	-	Fdmi	0.1	U.S. EPA, 1993
Fraction that is hare	-	Fhmi	0.1	U.S. EPA, 1993
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLomi	1.26	Schroeder and Mitchener (1971)
Fraction of time at site	-	Flocmi	1	assumed to be at Mackeno Tailings for the entire year
Intake of COC from water by body weight	mg/kg-d	Iwmi	1.45E-03	=Qwatmi*WatcMT*Flocmi/BWmi/1000 grams per liter
Intake of COC from sediment by body weight	mg/kg-d	Ismi	3.85E+00	=Qsedwmi*SedcMT*Flocmi/BWmi/1000 grams per kilogram

Intake of COC from aquatic vegetation by body weight	mg/kg-d	Iavmi	3.21E-02	=Qffwmi*Favmi*AqvegcMT*Flocmi/BWmi/1000 grams per kilogram
Intake of COC from benthic by body weight	mg/kg-d	Ibimi	4.91E-01	=Qffwmi*Fbimi*BencMT*Flocmi/BWmi/1000 grams per kilogram
Intake of COC from fish by body weight	mg/kg-d	Ifimi	2.50E-01	=Qffwmi*Ffimi*FishcMT*Flocmi/BWmi/1000 grams per kilogram
Intake of COC from ducks by body weight	mg/kg-d	Idmi	3.33E-01	=Qffwmi*Fdmi*DuckcMT*Flocmi/BWmi/1000 grams per kilogram
Intake of COC from hare by body weight	mg/kg-d	Ihmi	2.67E-03	=Qffwmi*Fhmi*HarecMT*Flocmi/BWmi/1000 grams per kilogram
Total intake	mg/kg-d	Itotmi	4.96E+00	=Iwmi+Ismi+Iavmi+Ibimi+Ifimi+Idmi+Ihmi
Screening Index - LOAEL	-	SImi	**3.94**	=Itotmi/ToxLomi
Moose - Entire Site (UKHM)				
Body weight	kg	BWmo	600	Canadian Wildlife Service (1997)
Water ingestion rate	g/d	Qwatmo	31300	U.S. EPA, 1993
Sediment ingestion rate	g DW/d	Qsedwmo	138	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwmo	23000	Canadian Wildlife Service (1997)
Fraction that is aquatic vegetation	-	Favmo	0.094	Belovsky *et al.* (1973)
Fraction that is browse	-	Fbwmo	0.9	Belovsky *et al.* (1973)
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLomo	1.26	Schroeder and Mitchener (1971)
Fraction of time at site	-	Flocmo	1	assumed to be at United Keno Hill Mine site for the entire year
Intake of COC from water by body weight	mg/kg-d	Iwmo	4.12E-04	=Qwatmo*WatcUKHM*Flocmo/BWmo/1000 grams per liter
Intake of COC from sediment by body weight	mg/kg-d	Ismo	5.24E-02	=Qsedwmo*SedcUKHM*Flocmo/BWmo/1000 grams per kilogram
Intake of COC from aquatic vegetation by body weight	mg/kg-d	Iavmo	5.69E-03	=Qffwmo*Favmo*AqvegcUKHM*Flocmo/BWmo/1000 grams per kilogram
Intake of COC from browse by body weight	mg/kg-d	Ibwmo	1.52E-02	=Qffwmo*Fbwmo*BrowsecUKHM*Flocmo/BWmo/1000 grams per kilogram
Total intake	mg/kg-d	Itotmo	7.38E-02	=Iwmo+Ismo+Iavmo+Ibwmo
Screening Index - LOAEL	-	SImo	0.06	=Itotmo/ToxLomo
Caribou - Entire Site (UKHM)				
Body weight	kg	BWc	135	ADF&G
Water ingestion rate	g/d	Qwatc	8200	U.S. EPA, 1993
Soil ingestion rate	g DW/d	Qsdwc	194	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwc	6457	U.S. EPA, 1993
Fraction that is forage	-	Ffc	0.11	based on Thomas and Barry (1991)
Fraction that is browse	-	Fbwc	0.11	based on Thomas and Barry (1991)
Fraction that is lichen	-	Flic	0.75	based on Thomas and Barry (1991)
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLoc	1.26	Schroeder and Mitchener (1971)
Fraction of time at site	-	Flocc	0.5	assumed to be at United Keno Hill Mine site for six months

Intake of COC from water by body weight	mg/kg-d	Iwc	2.40E-04	=Qwatc*WatcUKHM*Flocc/BWc/1000 grams per liter
Intake of COC from soil by body weight	mg/kg-d	Isc	1.27E-01	=Qsdwc*SoilcUKHM*Flocc/BWc/1000 grams per kilogram
Intake of COC from forage by body weight	mg/kg-d	Ifc	1.75E-03	=Qffwc*Ffc*ForagecUKHM*Flocc/BWc/1000 grams per kilogram
Intake of COC from browse by body weight	mg/kg-d	Ibwc	1.16E-03	=Qffwc*Fbwc*BrowsecUKHM*Flocc/BWc/1000 grams per kilogram
Intake of COC from lichen by body weight	mg/kg-d	Ilic	1.39E-01	=Qffwc*Flic*LichencUKHM*Flocc/BWc/1000 grams per kilogram
Total intake	mg/kg-d	Itotc	2.70E-01	=Iwc+Isc+Ifc+Ibwc+Ilic
Screening Index - LOAEL	-	SIc	0.21	=Itotc/ToxLoc
Bear - Entire Site (UKHM)				
Body weight	kg	BWb	225	Kronk 2002
Water ingestion rate	g/d	Qwatb	13000	U.S. EPA, 1993
Soil ingestion rate	g DW/d	Qsdwb	295	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwb	19650	U.S. EPA, 1993
Fraction that is forage	-	Ffb	0.33	Holcroft and Herrero 1991
Fraction that is berries	-	Fbrb	0.4	Holcroft and Herrero 1991
Fraction that is fish	-	Ffib	0.155	Holcroft and Herrero 1991
Fraction that is moose	-	Fmob	0.05	Holcroft and Herrero 1991
Fraction that is caribou	-	Fcb	0.05	Holcroft and Herrero 1991
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLob	1.26	Schroeder and Mitchener (1971)
Fraction of time at site	-	Flocb	1	assumed to be at United Keno Hill Mine site for the entire year
Intake of COC from water by body weight	mg/kg-d	Iwb	4.56E-04	=Qwatb*WatcUKHM*Flocb/BWb/1000 grams per liter
Intake of COC from soil by body weight	mg/kg-d	Isb	2.32E-01	=Qsdwb*SoilcUKHM*Flocb/BWb/1000 grams per kilogram
Intake of COC from forage by body weight	mg/kg-d	Ifb	1.92E-02	=Qffwb*Ffb*ForagecUKHM*Flocb/BWb/1000 grams per kilogram
Intake of COC from berries by body weight	mg/kg-d	Ibrb	5.31E-03	=Qffwb*Fbrb*BerriescUKHM*Flocb/BWb/1000 grams per kilogram
Intake of COC from fish by body weight	mg/kg-d	Ifib	1.13E-02	=Qffwb*Ffib*FishcUKHM*Flocb/BWb/1000 grams per kilogram
Intake of COC from moose by body weight	mg/kg-d	Imob	3.87E-04	=Qffwb*Fmob*MoosecUKHM*Flocb/BWb/1000
Intake of COC from caribou by body weight	mg/kg-d	Icb	9.74E-04	=Qffwb*Fcb*CariboucUKHM*Flocb/BWb/1000 grams per kilogram
Total intake	mg/kg-d	Itotb	2.70E-01	=Iwb+Isb+Ifb+Ibrb+Ifib+Imob+Icb
Screening Index - LOAEL	-	SIb	0.21	=Itotb/ToxLob
Fox - Mackeno Tailings (MT)				
Body weight	kg	BWf	4.5	U.S. EPA, 1993
Water ingestion rate	g/d	Qwatf	383	U.S. EPA, 1993
Soil ingestion rate	g DW/d	Qsdwf	2.6	calculated from Beyer *et al.*, 1994.
Food ingestion rate	g FW/d	Qffwf	310	U.S. EPA, 1993

Fraction that is berries	-	Fbrf	0.14	U.S. EPA, 1993
Fraction that is ducks	-	Fdf	0.422	U.S. EPA, 1993
Fraction that is hare	-	Fhf	0.43	U.S. EPA, 1993
Toxicity Reference Value - LOAEL	mg/kg-d	ToxLof	1.26	Schroeder and Mitchener (1971)
Fraction of time at site	-	Flocf	1	assumed to be at Mackeno Tailings for the entire year
Intake of COC from water by body weight	mg/kg-d	Iwf	1.24E-03	=Qwatf*WatcMT*Flocf/BWf/1000 grams per liter
Intake of COC from soil by body weight	mg/kg-d	Isf	1.07E-02	=Qsdwf*SoilcMT*Flocf/BWf/1000 grams per kilogram
Intake of COC from berries by body weight	mg/kg-d	Ibrf	4.90E-04	=Qffwf*Fbrf*BerriescMT*Flocf/BWf/1000 grams per kilogram
Intake of COC from ducks by body weight	mg/kg-d	Idf	4.40E-01	=Qffwf*Fdf*DuckcMT*Flocf/BWf/1000 grams per kilogram
Intake of COC from hare by body weight	mg/kg-d	Ihf	3.60E-03	=Qffwf*Fhf*HarecMT*Flocf/BWf/1000 grams per kilogram
Total intake	mg/kg-d	Itotf	4.56E-01	=Iwf+Isf+Ibrf+Idf+Ihf
Screening Index - LOAEL	-	SIf	0.36	=Itotf/ToxLof

D.2 HUMAN RECEPTORS

Table D.2 Sample Calculations for Human Receptors at the Historic Keno Hill Mine Site at South McQuesten Area for Arsenic

HUMAN HEALTH RISK ASSESSMENT SAMPLE CALCULATIONS — **Arsenic South McQuesten**

			Adult	Teen	Child	Toddler	Composite	
Human Characteristics								
Water ingestion rate	L/d	wira	1.5	1	0.8	0.6		Richardson 1997
Hare ingestion rate	kg/d	hira	6.12E-03	6.12E-03	4.53E-03	3.18E-03		Receveur *et al.* 1998
Marmot ingestion rate	kg/d	hmira	4.08E-03	4.08E-03	3.02E-03	2.12E-03		Receveur *et al.* 1998
Beaver ingestion rate	kg/d	bvira	3.33E-03	3.33E-03	2.46E-03	1.73E-03		Receveur *et al.* 1998
Moose ingestion rate	kg/d	mira	1.46E-01	1.46E-01	1.08E-01	7.59E-02		Receveur *et al.* 1998
Caribou ingestion rate	kg/d	cira	1.18E-02	1.18E-02	8.70E-03	6.11E-03		Receveur *et al.* 1998
Sheep ingestion rate	kg/d	shira	6.80E-04	6.80E-04	5.03E-04	3.54E-04		Receveur *et al.* 1998
Grouse ingestion rate	kg/d	gira	6.70E-04	6.70E-04	4.96E-04	3.48E-04		Receveur *et al.* 1998
Mallard ingestion rate	kg/d	dira	3.30E-04	3.30E-04	2.44E-04	1.72E-04		Receveur *et al.* 1998
Lab tea ingestion rate	kg/d	ltira	5.57E-04	5.57E-04	0.00E+00	0.00E+00		Receveur *et al.* 1998
Fish ingestion rate	kg/d	fira	2.16E-02	2.16E-02	1.75E-02	1.08E-02		Receveur *et al.* 1998
Berries ingestion rate	kg/d	bira	1.63E-03	1.63E-03	1.78E-03	1.56E-03		Receveur *et al.* 1998
Body weight	kg	BWa	70.7	59.7	32.9	16.5		Richardson 1997
Time at site	-	loca	0.125	0.125	0.125	0.125		Assumed (1.5 month/yr)
Soil ingestion rate	kg/d	sira	0.0000017	0.0000015	0.000012	0.000013		Richardson 2010
Air Inhalation Rate	m^3/d	aira	16.57	15.57	14.52	8.31		Allen *et al.* 2008
Skin surface area - total exposed	cm^2	SAea	9110	8000	5140	3010		Richardson 1997
Soil loading to exposed skin	kg/(cm^2-event)	SLha	1.88E-08	1.90E-08	2.03E-08	2.29E-08		Health Canada 2007
Exposure frequency	events/d	EFa	0.125	0.125	0.125	0.125		=1 event/d x loca
Fraction of time eating food from site	-	Ffooda	0.5	0.5	0.5	0.5		Assumed 6 months of a year
Toxicity Data - for Arsenic								
Dermal Relative Absorption Factor	-	RAF	0.03					Health Canada 2009
Reference Dose - oral exposure	mg/(kg d)	RfDo	-	-	-	-		Health Canada 2009
Reference Concentration - inhalation	mg/m3	RfDi	-					Health Canada 2009
Slope Factor - oral exposure	$(mg/(kg\ d))^{-1}$	SFo	1.8					Health Canada 2009
Unit Risk - inhalation	$(mg/m3)^{-1}$	URi	6.4					Health Canada 2009
Concentrations								
water	mg/L	watc	8.81E-03					95% UCLM of measured conc at Galena Hill
soil	mg/kg (dw)	soilc	9.84E+01					95% UCLM of measured conc at Galena Hill
air	mg/m^3	airconc	7.48E-08					estimated from soil concentration
hare	mg/kg (ww)	harec	1.07E-01					predicted conc at Galena Hill

marmot	mg/kg (ww)	marmotc	6.48E-02					predicted conc at Galena Hill
beaver	mg/kg (ww)	beaverc	2.87E-01					predicted conc at Galena Hill
moose	mg/kg (ww)	moosec	8.85E-02					predicted conc at Galena Hill
caribou	mg/kg (ww)	caribouc	2.23E-01					predicted conc at Galena Hill
sheep	mg/kg (ww)	sheepc	1.13E-01					predicted conc at Galena Hill
grouse	mg/kg (ww)	grousec	1.00E+00					predicted conc at Galena Hill
mallard	mg/kg (ww)	duckc	6.17E+00					predicted conc at Galena Hill
lab tea	mg/kg (ww)	labteac	1.86E-02					maximum measured lab tea conc at Galena Hill
fish	mg/kg (ww)	fishc	1.87E-01					maximum measured conc at Galena Hill
berries	mg/kg (ww)	berryc	7.30E-03					95% UCLM of measured conc at Galena Hill
Dose and Risk Calculations								
dose from water	mg/(kg d)	Dwater_a	2.34E-05	1.84E-05	2.68E-05	4.00E-05		=watc*wira/BWa*loca
dose from ingestion of soil	mg/(kg d)	Dsoil_a	2.96E-07	3.09E-07	4.49E-06	9.69E-06		=soilc*sira/BWa*loca
hare	mg/(kg d)	Dhare_a	4.63E-06	5.48E-06	7.36E-06	1.03E-05		=harec*hira/BWa*Ffooda
marmot	mg/(kg d)	Dmarmot_a	1.87E-06	2.21E-06	2.97E-06	4.16E-06		=marmotc*hmira/BWa*Ffooda
beaver	mg/(kg d)	Dbeaver_a	6.75E-06	8.00E-06	1.07E-05	1.50E-05		=beaverc*bvira/BWa*Ffooda
moose	mg/(kg d)	Dmoose_a	9.14E-05	1.08E-04	1.45E-04	2.04E-04		=moosec*mira/BWa*Ffooda
caribou	mg/(kg d)	Dcaribou_a	1.85E-05	2.20E-05	2.95E-05	4.13E-05		=caribouc*cira/BWa*Ffooda
sheep	mg/(kg d)	Dsheep_a	5.45E-07	6.45E-07	8.66E-07	1.21E-06		=sheepc*shira/BWa*Ffooda
grouse	mg/(kg d)	Dgrouse_a	4.75E-06	5.62E-06	7.55E-06	1.06E-05		=grousec*gira/BWa*Ffooda
mallard	mg/(kg d)	Dduck_a	1.44E-05	1.70E-05	2.29E-05	3.21E-05		=duckc*dira/BWa*Ffooda
lab tea	mg/(kg d)	Dlabtea_a	7.33E-08	8.68E-08	0.00E+00	0.00E+00		=labteac*ltira/BWa*Ffooda
fish	mg/(kg d)	Dfish_a	2.85E-05	3.38E-05	4.97E-05	6.11E-05		=fishc*fira/BWa*Ffooda
berries	mg/(kg d)	Dberry_a	8.42E-08	9.97E-08	1.97E-07	3.46E-07		=berryc*bira/BWa*Ffooda
dose from ingestion	mg/(kg d)	Dingestion_a	1.95E-04	2.22E-04	3.08E-04	4.30E-04		=Dwater_a+Dsoil_a+Dhare_a+Dmarmot_a +Dbeaver_a+Dmoose_a+Dcaribou_a +Dsheep_a+Dgrouse_a+Dduck_a+Dlabtea_a +Dfish_a+Dberry_a
dose from dermal exposure	mg/(kg d)	Ddermal_a	8.94E-07	9.40E-07	1.17E-06	1.54E-06		=soilc*SAea*SLha*RAF*EFa/BWa
Hazard Quotient - ingestion+dermal	-	HQing_a	-	-	-	-		=(Dingestion_a+Ddermal_a)/RfDo
Hazard Quotient - inhalation	-	HQinh_a	-	-	-	-		=airconc/RfDi*loca
Total Hazard Quotient	-	HQ_adult	-	-	-	-		=HQing_a+HQinh_a
Exposure Duration	year	exp_a	61	8	7	4		assumed
Average Exposure Period	year	avgTime	80	80	80	80		carcinogenic (lifetime)
Risk - Ingestion+Dermal	-	Ring_a	**2.69E-04**	4.01E-05	4.87E-05	3.40E-05	**3.92E-04**	=(Dingestion_a+Ddermal_a) *(exp_a/avgTime)*SFo (add up all life stages for composite)
Risk - Inhalation	-	Rinh_a	4.56E-08	5.99E-09	5.24E-09	2.62E-09	5.95E-08	=airconc*loca*(Exp_a/AvgTime) *URi (add up all life stages for composite)
Total Risk	-	Rtot_a	**2.69E-04**	4.01E-05	4.88E-05	3.40E-05	**3.92E-04**	=Ring_a+Rinh_a

Calculations are for composite receptor only. Risks are not reported for teens, toddlers and children.

Table D.3 Sample Calculations for Human Receptors at the Historic Keno Hill Mine Site at South McQuesten Area for Nickel

HUMAN HEALTH RISK ASSESSMENT SAMPLE CALCULATIONS — **Nickel, South McQuesten**

Human Characteristics			**Adult**	**Teen**	**Child**	**Toddler**	**Composite**	
Water ingestion rate	L/d	wira	1.5	1	0.8	0.6		Richardson 1997
Hare ingestion rate	kg/d	hira	6.12E-03	6.12E-03	4.53E-03	3.18E-03		Receveur *et al.* 1998
Marmot ingestion rate	kg/d	hmira	4.08E-03	4.08E-03	3.02E-03	2.12E-03		Receveur *et al.* 1998
Beaver ingestion rate	kg/d	bvira	3.33E-03	3.33E-03	2.46E-03	1.73E-03		Receveur *et al.* 1998
Moose ingestion rate	kg/d	mira	1.46E-01	1.46E-01	1.08E-01	7.59E-02		Receveur *et al.* 1998
Caribou ingestion rate	kg/d	cira	1.18E-02	1.18E-02	8.70E-03	6.11E-03		Receveur *et al.* 1998
Sheep ingestion rate	kg/d	shira	6.80E-04	6.80E-04	5.03E-04	3.54E-04		Receveur *et al.* 1998
Grouse ingestion rate	kg/d	gira	6.70E-04	6.70E-04	4.96E-04	3.48E-04		Receveur *et al.* 1998
Mallard ingestion rate	kg/d	dira	3.30E-04	3.30E-04	2.44E-04	1.72E-04		Receveur *et al.* 1998
Lab tea ingestion rate	kg/d	ltira	5.57E-04	5.57E-04	0.00E+00	0.00E+00		Receveur *et al.* 1998
Fish ingestion rate	kg/d	fira	2.16E-02	2.16E-02	1.75E-02	1.08E-02		Receveur *et al.* 1998
Berries ingestion rate	kg/d	bira	1.63E-03	1.63E-03	1.78E-03	1.56E-03		Receveur *et al.* 1998
Body weight	kg	BWa	70.7	59.7	32.9	16.5		Richardson 1997
Time at site	-	loca	0.125	0.125	0.125	0.125		Assumed (1.5 month/yr)
Soil ingestion rate	kg/d	sira	0.0000017	0.0000015	0.000012	0.000013		Richardson 2010
Air Inhalation Rate	m^3/d	aira	16.57	15.57	14.52	8.31		Allen *et al.* 2008
Skin surface area - total exposed	cm^2	SAea	9110	8000	5140	3010		Richardson 1997
Soil loading to exposed skin	kg/(cm^2-event)	SLha	1.88E-08	1.90E-08	2.03E-08	2.29E-08		Health Canada 2007
Exposure frequency	events/d	EFa	0.125	0.125	0.125	0.125		=1 event/d x loca
Fraction of time eating food from site	-	Ffooda	0.5	0.5	0.5	0.5		Assumed 6 months of a year
Toxicity Data - for Arsenic								
Dermal Relative Absorption Factor	-	RAF	0.085					Health Canada 2009
Reference Dose - oral exposure	mg/(kg d)	RfDo	0.011	0.011	0.011	0.011		Health Canada 2009
Reference Concentration - inhalation	mg/m3	RfDi	0.00002					Health Canada 2009
Slope Factor - oral exposure	$(mg/(kg\ d))^{-1}$	SFo	-					Health Canada 2009
Unit Risk - inhalation	$(mg/m3)^{-1}$	URi	1.3					Health Canada 2009
Concentrations								
water	mg/L	watc	1.07E-02					95% UCLM of measured conc at Galena Hill
soil	mg/kg (dw)	soilc	1.12E+02					95% UCLM of measured conc at Galena Hill
air	mg/m^3	airconc	8.49E-08					estimated from soil concentration
hare	mg/kg (ww)	harec	3.67E-01					predicted conc at Galena Hill
marmot	mg/kg (ww)	marmotc	2.08E-01					predicted conc at Galena Hill
beaver	mg/kg (ww)	beaverc	2.59E+00					predicted conc at Galena Hill

moose	mg/kg (ww)	moosec	1.44E-01						predicted conc at Galena Hill
caribou	mg/kg (ww)	caribouc	8.37E-02						predicted conc at Galena Hill
sheep	mg/kg (ww)	sheepc	3.50E-01						predicted conc at Galena Hill
grouse	mg/kg (ww)	grousec	4.12E-01						predicted conc at Galena Hill
mallard	mg/kg (ww)	duckc	7.95E-02						predicted conc at Galena Hill
lab tea	mg/kg (ww)	labteac	1.77E-01						maximum measured lab tea conc at Galena Hill
fish	mg/kg (ww)	fishc	1.69E+00						maximum measured conc at Galena Hill
berries	mg/kg (ww)	berryc	2.14E-01						95% UCLM of measured conc at Galena Hill
Dose and Risk Calculations									
dose from water	mg/(kg d)	Dwater_a	2.84E-05	2.24E-05	3.25E-05	4.86E-05			=watc*wira/BWa*loca
dose from ingestion of soil	mg/(kg d)	Dsoil_a	3.36E-07	3.51E-07	5.09E-06	1.10E-05			=soilc*sira/BWa*loca
hare	mg/(kg d)	Dhare_a	1.59E-05	1.88E-05	2.52E-05	3.53E-05			=harec*hira/BWa*Ffooda
marmot	mg/(kg d)	Dmarmot_a	5.99E-06	7.10E-06	9.53E-06	1.34E-05			=marmotc*hmira/BWa*Ffooda
beaver	mg/(kg d)	Dbeaver_a	6.09E-05	7.22E-05	9.69E-05	1.36E-04			=beaverc*bvira/BWa*Ffooda
moose	mg/(kg d)	Dmoose_a	1.49E-04	1.76E-04	2.36E-04	3.31E-04			=moosec*mira/BWa*Ffooda
caribou	mg/(kg d)	Dcaribou_a	6.96E-06	8.24E-06	1.11E-05	1.55E-05			=cariboucc*cira/BWa*Ffooda
sheep	mg/(kg d)	Dsheep_a	1.68E-06	1.99E-06	2.68E-06	3.75E-06			=sheepc*shira/BWa*Ffooda
grouse	mg/(kg d)	Dgrouse_a	1.95E-06	2.31E-06	3.11E-06	4.35E-06			=grousec*gira/BWa*Ffooda
mallard	mg/(kg d)	Dduck_a	1.86E-07	2.20E-07	2.95E-07	4.13E-07			=duckc*dira/BWa*Ffooda
lab tea	mg/(kg d)	Dlabtea_a	6.97E-07	8.26E-07	0.00E+00	0.00E+00			=labteac*ltira/BWa*Ffooda
fish	mg/(kg d)	Dfish_a	2.58E-04	3.05E-04	4.49E-04	5.52E-04			=fishc*fira/BWa*Ffooda
berries	mg/(kg d)	Dberry_a	2.47E-06	2.93E-06	5.79E-06	1.02E-05			=berryc*bira/BWa*Ffooda
dose from ingestion	mg/(kg d)	Dingestion_a	5.32E-04	6.19E-04	8.77E-04	1.16E-03			=Dwater_a+Dsoil_a+Dhare_a+Dmarmot_a +Dbeaver_a+Dmoose_a+Dcaribou_a +Dsheep_a+Dgrouse_a+Dduck_a +Dlabtea_a+Dfish_a+Dberry_a
dose from dermal exposure	mg/(kg d)	Ddermal_a	2.87E-06	3.02E-06	3.77E-06	4.95E-06			=soilc*SAea*SLha*RAF*EFa/BWa
Hazard Quotient - ingestion+dermal	-	HQing_a	0.049	0.057	0.080	0.106			=(Dingestion_a+Ddermal_a)/RfDo
Hazard Quotient - inhalation	-	HQinh_a	5.31E-04	5.31E-04	5.31E-04	5.31E-04			=airconc/RfDi*loca
Total Hazard Quotient	-	HQ_adult	4.92E-02	5.71E-02	8.06E-02	1.07E-01			=HQing_a+HQinh_a
Exposure Duration	year	exp_a	61	8	7	4			assumed
Average Exposure Period	year	avgTime	80	80	80	80			carcinogenic (lifetime)
Risk - Ingestion+Dermal	-	Ring_a	-	-	-	-	-		=(Dingestion_a+Ddermal_a) *(exp_a/avgTime) *SFo (add up all life stages for composite)
Risk - Inhalation	-	Rinh_a	1.05E-08	1.38E-09	1.21E-09	6.04E-10	1.37E-08		=airconc*loca*(Exp_a/AvgTime)*URi (add up all life stages for composite)
Total Risk	-	Rtot_a	1.05E-08	1.38E-09	1.21E-09	6.04E-10	1.37E-08		=Ring_a+Rinh_a

Calculations are for composite receptor only. Risks are not reported for teens, toddlers and children.