APPENDIX 25-D
KSM COUNTRY FOODS SCREENING LEVEL RISK ASSESSMENT FOR THE MINE SITE

Rescan™

Seabridge Gold Inc.

KSM PROJECT
Country Foods Screening Level Risk Assessment for the Mine Site

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Executive Summary

This report represents the screening level risk assessment (SLRA) for human health risks from the consumption of country foods harvested from near the proposed KSM Project during its operation and closure; the report has been conducted by Rescan Environmental Services Ltd. Country foods are animals, plants, and fungi used by humans for nutritional or medicinal purposes that are harvested through hunting, fishing, or gathering of vegetation. This SLRA addresses potential effects to these foods from the Mine Site, which includes the pits, the Water Storage Facility, and the Water Treatment and Energy Recovery Area. The Processing and Tailing Management Area is addressed in a separate SLRA.

The information contained in this SLRA is intended to support the Application for an Environmental Assessment Certificate/Environmental Impact Statement. The methodology for the country foods baseline assessment was based on Health Canada's guidelines for assessing food issues in environmental impact assessments (Health Canada 2010a, 2010b, 2010c).

The country foods evaluated were moose (*Alces alces*), snowshoe hare (*Lepus americanus*), grouse (*Phasianidae* sp.), a mixture of berries consisting of highbush cranberry (*Viburnum edule),* huckleberry *(Vaccinium membanaceum),* and blueberry *(V. ovalifolium*). An assessment of potential health risks from the consumption of Dolly Varden (*Salvelinus malma malma)* was not included because there is no evidence that fishing of Dolly Varden occurs at Sulphurets Creek and Unuk River. Salmon species were not evaluated because they are anadromous and reside primarily in marine waters, except during early juvenile life stages and spawning migrations. The quality of adult salmon would reflect their long-term exposure to marine environments, rather than their short-term exposure to freshwater environments during their spawning migration. There is no evidence that fishing of salmon occurs at the Unuk River at the confluence of Sulphurets Creek.

The SLRA focused on metals because the KSM Project is a proposed metal mine. Seventeen metals as well as fluoride were selected for evaluation in this SLRA. The contaminants of potential concern were selected based on screening of the soil, sediment, and surface water baseline data collected during baseline studies from areas downstream of the Mine site. Water quality predictions for the operation and closure scenarios of the Mine Site were modelled against the Canadian Council of Ministers of the Environment water quality guidelines and British Columbia maximum water criteria for the protection of freshwater aquatic life. Metal concentrations in foods were modelled for moose, snowshoe hare, and grouse muscle tissue, while berries were collected for laboratory analysis during baseline studies.

This SLRA predicted no unacceptable risks to people from consuming moose, snowshoe hare, grouse, and berries during baseline conditions, operation and closure. Based on the measured baseline conditions and the modelled operation and closure conditions, country food quality is not expected to change substantially due to the Project. This means that country food harvesters can continue to consume moose, snowshoe hare, grouse and other country foods at the rates and frequencies to which they are accustomed.

Country Foods Screening Level Risk Assessment for the Mine Site

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

Table **Page**

1 Introduction

1.1 Overview

This Country Foods Screening Level Risk Assessment (SLRA) supplements Section 25.7 of the KSM Project (the Project) Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS). The only potential residual effects on human health from country foods will be from the wildlife (moose, snowshoe hare, and grouse) that may incidentally ingest soil, vegetation, and water downstream of the Mine Site during operation and closure, as explained in Section 25.7.3. The potential effects of the construction phase on human health are expected to be lower than any effects from the operation and closure phases. Because the inherent nature of an SLRA is to be conservative, the SLRA assessed possible worst-case scenarios and therefore the construction phase was not included in the assessment.

The habitat of wildlife important for human consumption (moose, grouse, snowshoe hare) is low-elevation forests below and west of the proposed pits, the Rock Storage Facility and the Water Storage Facility. Therefore, potential for metal uptake from these Project components were not evaluated in the assessment. The wildlife habitat is also largely outside the predicted dust deposition area and therefore potential effects from dustfall on soil and vegetation was not included in the Country Foods SLRA.

This Country Foods SLRA presents the predicted risks associated with consuming country foods harvested in the area of the Project downstream of the Mine Site when the proposed mine is operational and during closure. Post-closure was not included in the SLRA because of high uncertainties with succession in vegetation, bioaccumulation factors, and model assumptions. The purpose of this SLRA was to evaluate the quality of moose, grouse, snowshoe hare, and berries that are potentially eaten by harvesters (e.g., guide outfitters, First Nations, trappers) downstream of the Mine Site and determine whether there could be risks to human health from consuming these foods during mine operation and closure. The methodology for the country foods assessment was based on Health Canada's guidelines for assessing country foods (Health Canada 2004).

For comparative purposes, the country foods baseline risks for moose, grouse, snowshoe hare, and berries (Rescan 2010) were compared to those of the operation and closure phase risks. This SLRA predicted no unacceptable risks to people from consuming these country foods during baseline conditions, operation, and closure. Based on the measured baseline conditions and the modelled operation/closure conditions, country food quality is not expected to change substantially. This means that country food harvesters can continue to consume these country foods at the rates and frequencies to which they are accustomed.

1.2 Methodology

The methodology for the SLRA was based on Health Canada's guidelines for assessing food issues in environmental impact assessments (Health Canada 2010a, 2010b, 2010c).

The human health risk assessment was divided into five stages.

1. Problem formulation: The conceptual model for conducting the country foods study was developed in the problem formulation stage. This stage identified the contaminants of potential concerns (COPCs) and human receptor characteristics.
2. Exposure assessment: The measured or predicted metal concentrations in country foods were integrated with human consumption characteristics to calculate the estimated daily intake (EDI) of COPCs.
3. Toxicity assessment: The tolerable daily intake (TDI) levels of daily exposure that can be taken into the body without appreciable health risk were identified.
4. Risk characterization: The exposure and effects assessments were integrated by comparing the EDIs with TDIs to produce quantitative risk estimates. In addition, the recommended maximum weekly intake (RMWI) of each country food was calculated.
5. Uncertainty analysis and data gaps: The assumptions made throughout the study and their effects on the conclusions were evaluated. Data gaps were identified and addressed.

2 Problem Formulation

2.1 Introduction

The problem formulation stage describes the environmental conditions required for consideration in the risk assessment and outlines how human health risks could occur. This stage requires identifying data that are needed to accurately assess the risk to country food harvesters downstream of the Mine site, specifically:

- identify the most relevant country foods harvested downstream of the Mine site during the Project's operation and closure phases;
- identify the COPCs during the Project's operation and closure phases;
- identify the human receptors and the relevant life stages (e.g., adults and toddlers) that harvest and consume country foods from the Project area during the operation and closure phases; and
- identify the relevant human exposure pathways.

2.2 Country Foods Selected for Evaluation

In the *KSM Project: 2009 Country Foods Baseline Report* (Rescan 2010), the country foods selected for evaluation for the baseline included: moose (*Alces alces*), snowshoe hare (*Lepus americanus*), grouse (*Phasianidae sp.*) and highbush cranberry (*Viburnum edule*). These species were selected as they were reportedly harvested by the country foods harvesters.

For the operation and closure phases, moose, snowshoe hare, and grouse may be exposed to the predicted elevated metal concentrations if they drink water from the creeks and streams downstream of the Mine Site. Moose, snowshoe hare, and grouse are unlikely to approach the Mine Site due to inadequate habitat needs (dense forest cover, food) not found in alpine and sub-alpine terrain, and sensory disturbance from mining operations. Moose have not been observed along Sulphurets Creek (Chapter 18, Wildlife and Wildlife Habitat; Figure 18.1-1), but use habitat in the Unuk River Valley; however, the Unuk River Valley near the proposed Project is not classified as high quality moose habitat. Snowshoe hare and grouse require dense brush and trees to be protected from predators. The predicted dustfall from mining operations at the Mine Site will not affect the Unuk River and the moose receptor site located in the Unuk River Valley (Chapter 7, Figure 7.8.33).

Moose and grouse were selected for evaluation during the operation and closure scenarios because they are important country foods identified by Nisga'a Nation (moose and grouse), wilp Skii km Lax Ha (moose and grouse), Tahltan Nation (moose), Gitxsan Nation (moose and grouse), and Gitanyow First Nation, including wilp Wii'litsxw (moose; Chapter 29, Nisga'a Nation Interests; Chapter 30, First Nations and Métis Interests). Moose was also identified as the most commonly harvested animal by non-aboriginal hunters in the Wildlife Management Unit 6-21, which is the unit relevant for the Mine Site (Chapter 23, Land Use). Animals would also have direct exposure to soil, vegetation, and water downstream of the Mine Site.

Snowshoe hare were not identified as being affected by mine development (Chapter 18, Section 18.5.2), but have been included in the SLRA as a representative of a small herbivorous mammal. Snowshoe hare prefer young forests with abundant understories for protection from predators. Therefore, snowshoe hare are not expected to approach the Mine Site in subalpine and alpine habitats.

Salmon were not identified as being significantly affected by mine development because they are anadromous and reside primarily in marine waters, except during early juvenile life stages and spawning migrations (Appendix 25-B). The quality of adult salmon that may be harvested from the study area would reflect their long-term exposure to marine environments, rather than the short-term exposure to freshwater environments during their spawning migration. Adult salmon do not eat during their migration, further limiting their exposure to the freshwater environment. Metal uptake into fertilized fish eggs is limited by the process of water hardening of the chorion (an extracellular coat surrounding the fish egg; Gonzales-Doncel et al. 2003). Therefore, salmon were not included in the effects assessment.

Metal tissue concentrations in non-migratory Dolly Varden from the Unuk River and the lower Sulphurets Creek were analyzed during baseline studies (Chapter 15). Although winter fishing activities in Gitxsan Nation claimed territory and in the Skii km La Hax asserted territory include fishing for Dolly Varden and trout (Appendix 30-D), fishing activities potentially affected by the Project are only reported to occur along the Bell-Irving River corridor. Aboriginal fishing is not reported to occur along the Unuk River near the Mine Site. There is no guided angling or commercial fishery on the Unuk River within Canadian waters (Chapter 23, Appendix 23-A, Non-Traditional Land Use Baseline Report). Therefore, potential human health effects from the consumption of fish near the Mine Site were not assessed.

2.3 Contaminants of Potential Concern Selected for Evaluation

The proposed Project is a gold and copper mine. Metals occur naturally in the environment as a result of rock weathering and other geological processes. Mining operations (blasting, crushing, transport) mobilize metals that are sequestered in the rocks and ore. Metals concentrations in the water, soil, and sediment that exceeded applicable regulatory guidelines were assessed for their potential to affect human health.

Specific metals were selected as COPCs if they met at least one of the following four criteria:

1. the maximum baseline metal concentration in soil (Chapter 8, Appendix 8-A) exceeded Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for residential and park land (CCME 2010a);
2. the maximum baseline metal concentration in the water (Chapter 14, Appendix 14-A) exceeded the CCME or British Columbia water quality guidelines for the protection of aquatic life (BC MOE 2006; CCME 2010b);

3. the baseline metal concentration in the sediment during baseline studies was greater than the CCME or British Columbia sediment quality guidelines for the protection of aquatic life (CCME 2002; BC MOE 2006), and/or
4. the concentration of a metal in the water that was modelled downstream of the Mine Site (compliance points SC3, UR1, UR2) in the operation and closure scenarios was greater than the CCME or British Columbia maximum water quality guidelines for the protection of aquatic life (BC MOE 2006; CCME 2010b).

Table 2.3-1 presents the metals that were selected for evaluation. Shaded values indicate concentrations that were above the applicable guideline. A total of 17 metals and one anion were selected as COPCs for evaluation. These metals were: aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, tin, vanadium, and zinc.

The maximum concentrations of total iron in the surface waters have exceeded the CCME guideline for the protection of freshwater aquatic life (CCME 2010b). Despite the exceedance in the surface waters, iron was not selected as a COPC. Iron is the second most abundant metal in the earth's crust and is abundant in soils and sediment where it is tightly bound as largely insoluble iron (III) oxide and not available for biological uptake. There is no soil guideline for iron (CCME 2010a). Furthermore, iron is an essential element as it is a required component in blood cells for the transportation of oxygen throughout the body. There is no toxicity reference value (TRV) for iron and therapeutic doses to treat iron deficiencies (60 mg/day of ferrous iron; (Allen 2002) exceed environmental concentrations of biologically available dissolved iron. Because iron is an essential element for both wildlife and humans and since environmental exposure to iron from food consumption would not lead to adverse health effects, iron was not evaluated further in this study.

Mercury and selenium were selected as COPCs due to their potential to bioaccumulate and due to their baseline and predicted exceedance of CCME and BC water quality guidelines for the protection of freshwater aquatic life.

It is also noted that maximum measured and modelled concentrations of sulphate exceeded the BC water quality guideline for the protection of freshwater aquatic life during baseline conditions, operation, and closure in Sulphurets Creek (BC MOE 2006). Despite the exceedance, sulphate was not selected as a COPC. Sulphate has a high toxicity threshold; for instance, cattle can tolerate concentrations of sodium sulphate in their drinking-water up to 2,610 mg/L (corresponding to 527 mg/kg of body weight per day) for periods up to 90 days with no signs of toxicity, except for changes in methaemoglobin and sulfhaemoglobin levels (Digesti and Weeth 1976). This is more than twenty times the concentration observed in water downstream of the Mine Site. Sulphate does not bioaccumulate and is used as additives in the food industry (Codex Alimentarius Commission 1992). Sulphur is an essential element as it is a required component of amino acids and proteins. Humans excrete high doses of sulphate efficiently and it has not been possible to set a health-based standard for sulphate (WHO 2004). Because sulphate is an essential element for both wildlife and humans and since environmental exposure to sulphate from food consumption would not lead to adverse health effects, sulphate was not evaluated further in this assessment.

Modelled fluoride concentrations downstream of the Mine Site exceeded the British Columbia water quality guidelines under baseline conditions, but not during operation and closure scenarios. Therefore, fluoride was not included in the assessment.

2.4 Human Receptors

Human receptors are people who consume country foods as a substantial proportion of their total diet. Essential nutrients, vitamins, and minerals occur naturally in food and are required for human health. Many metals are essential at low doses, but may cause adverse health effects at high doses.

Health effects from chemicals are generally divided into two categories: threshold (i.e., non-carcinogenic) and non-threshold (i.e., carcinogenic) response chemicals. These two types of chemicals are evaluated differently. Both adults (older than 19 years of age) and toddlers (six months to four years) were evaluated for their susceptibility to the COPCs. Toddlers are most susceptible to chemicals with threshold response levels (non-carcinogenic) because of their higher ingestion rate per unit of body weight and food absorption rates relative to other age groups (Health Canada 2010c). If risks are found acceptable to the toddler receptor, then they would also be acceptable to all other potential receptors. For non-threshold responses to metals, an adult was the evaluated receptor as recommended by Health Canada.

2.5 Human Exposure Pathways

Human exposure pathways are the routes by which people are exposed to chemicals through ingestion of country foods.

Metal concentrations in the water of the Unuk River downstream from the confluence with Sulphurets Creek are predicted to change. Moose, hare, and grouse that drink the water and ingest sediments may be exposed to these COPCs. The bulk of the soil ingested by herbivores comes from the roots of consumed vegetation. Because dust from the Mine Site is not predicted to affect the Unuk River habitat, baseline soil and plant COPC concentrations were used to predict COPC concentrations in wildlife using the food chain model. A fraction of the ingested COPCs would be absorbed and retained in the muscle tissue of these animals. Human receptors that eat moose, hare, or grouse that frequent habitat downstream of the Mine Site will be indirectly exposed to COPCs originating from the Mine Site. Human exposures may result even if people do not physically enter the Mine Site because animals will travel downstream from the Mine Site.

Table 2.3-1. Metals Evaluated and Rationale for Inclusion as COPC into the SLRA for the Mine Site

	Maximum Soil Concentration in 0-10 cm, n=59 (2009) mg/kg	CCME Soil Guideline (Agricultural) mg/kg	Maximum Sediment Concentration Unuk River, n=64 (2008-2012) mg/kg	CCME Sediment Guideline ISQG mg/kg	BC Sediment Guideline mg/kg	Maximum Water Concentration at Baseline in Sulphurets Cr. and Unuk R.[1] (2007-2011) mg/L (total metals)	Water Concentration at Mine Site[2] Operation years 1-50 mg/L (total metals)	Water Concentration at Mine Site[2] Closure years 51-55 mg/L (total metals)	CCME Water Guideline Freshwater Aquatic Life mg/L	BC Max. Water Criteria Freshwater Aquatic Life mg/L	Inclusion in SLRA
Aluminum (Al)	39,300	ng	23,200	ng	ng	**22.4**	**7.35**	**7.98**	0.10	ng	**Y**
Antimony (Sb)	15.0	ng	26.0	ng	ng	0.00867	0.00146	0.0015	ng	ng	**N**
Arsenic (As)	**169**	12	**117**	5.9	5.9	**0.0590**	**0.01200**	**0.0129**	0.01	0.05	**Y**
Barium (Ba)	**1,110**	750	589	ng	ng	0.410	0.157	0.168	ng	ng	**Y**
Beryllium (Be)	**6.47**	4	1.20	ng	ng	0.000840	0.00087	0.000847	ng	ng	**Y**
Bismuth (Bi)	10.0	ng	10.0	ng	ng	0.000730	-	-	ng	ng	**N**
Cadmium(Cd)	**1.52**	1.4	**25.4**	0.60	0.60	**0.00559**	**0.001140**	**0.00122**	0.00001-0.00007[3]	ng	**Y**
Calcium (Ca)	16,000	ng	40,000	ng	ng	80.0	60.4	61.2	ng	ng	**N**
Chromium (Cr)	**288**	64	**80.6**	37.3	37.3	**0.0387**	**0.0105**	**0.0112**	0.01	ng	**Y**
Cobalt (Co)	**123**	40	32.0	ng	ng	0.0159	0.00526	0.00568	ng	0.11	**Y**
Copper (Cu)	**1,060**	63	**214**	35.7	35.7	**0.432**	**0.116**	**0.126**	0.002-0.048[3]	0.002-0.0236[3]	**Y**
Iron (Fe)	373,000	ng	**78,100**	ng	21,200	**36.6**	**12.2**	**13.2**	0.30	1.00	**N**
Lead (Pb)	69.0	70	36.0	35	35	**0.0334**	**0.00624**	**0.00674**	0.001-0.0092[3]	0.125-0.955[3]	**Y**
Lithium (Li)	55.40	ng	43.2	ng	ng	0.0138	0.00551	0.00571	ng	ng	**N**
Magnesium (Mg)	30,500	ng	18,100	ng	ng	13.7	6.15	6.45	ng	ng	**N**
Manganese (Mn)	13,200	ng	1,520	ng	ng	0.973	0.31	0.333	ng	0.54-3.075[3]	**N**
Mercury (Hg)	2.72	6.6	0.56	0.17	0.17	**0.0000960**	**0.000033**	**0.0000343**	0.000026	ng	**Y**
Molybdenum (Mo)	**154**	5	20.3	ng	ng	0.00830	0.00406	0.00336	0.07	2.00	**Y**
Nickel (Ni)	**120**	50	**157**	ng	16	0.0289	0.00938	0.0101	0.034-0.180[3]	ng	**Y**
Phosphorus (P)	8,510	ng	2,320	ng	ng	1.41	-	-	ng	ng	**N**
Potassium (K)	4,060	ng	2,180	ng	ng	6.17	-	-	ng	ng	**N**
Selenium (Se)	**10.8**	1	19.1	ng	5	**0.00367**	**0.00512**	**0.00491**	0.001	ng	**Y**
Silver (Ag)	5.00	20	**2.30**	ng	0.5	**0.0240**	**0.000172**	**0.000186**	0.0001	0.0001-0.003[3]	**Y**
Sodium (Na)	4,650	ng	1,720	ng	ng	4.30	-	-	ng	ng	**N**
Strontium (Sr)	270	ng	152	ng	ng	0.396	-	-	ng	ng	**N**
Thallium (Tl)	0.50	1	0.612	ng	ng	0.000266	0.000102	0.000107	0.0008	ng	**N**
Tin (Sn)	**21.3**	5	2.50	ng	ng	0.0700	-	-	ng	ng	**Y**
Titanium (Ti)	6,760	ng	1,620	ng	ng	1.60	-	-	ng	ng	**N**
Vanadium (V)	**351**	130	157	ng	ng	0.0928	0.0309	0.0333	ng	ng	**Y**
Zinc (Zn)	**236**	200	**1,460**	123	123	**0.395**	**0.0914**	**0.0986**	0.03	0.033-0.130[3]	**Y**
WAD-Cyanide (WAD-CN)	nd	-	nd	-	-	0.00120	0.000669	0.000717	ng	0.01	**N**
Fluoride (F)	nd	-	nd	-	-	**0.157**	0.0881	0.0837	0.12	0.8-1.67[3]	**Y**
Nitrate (NO_3)	nd	-	nd	-	-	0.446	1.64	0.172	2.94	32.8	**N**
Sulphate (SO_4)	nd	-	nd	-	-	**153**	**158**	**156**	ng	100	**N**

Highlighted and bolded values are higher than guideline

ng no guideline

nd not determined

[1] SC3, UR0, ECM7, ECM8, CC1, UR1A, UR1, UR2

[2] maximum of modelled monthly predictions using the mean water quality data as source term and assuming normal flow; UR1, UR2, SC2, and SC3 were averaged

[3] Guideline is hardness-dependent and applicable range is provided

3 Exposure Assessment

3.1 Introduction

The amount of COPCs that people are exposed to from consuming country foods depends on several factors:

- the concentration of COPCs in moose, snowshoe hare, and grouse tissue from ingesting environmental media (e.g., vegetation, water, and soil) downstream of the Mine Site;
- the concentration of COPCs in berries near the Mine Site; and
- human receptor characteristics (e.g., consumption amount, frequency, body weight).

These factors are considered when calculating the EDI of COPCs through consuming country foods. EDIs are based on modelled food concentrations and the consumption rates and frequencies assumed in the country foods baseline assessment.

3.2 Country Food COPC Concentrations

COPC concentrations in moose, snowshoe hare, and grouse tissue were estimated using a food chain model. The food chain model predicted the concentration of metals in moose, snowshoe hare, and grouse muscle tissue from metal concentrations in the surrounding environmental media (i.e., water, soil, and vegetation) under the baseline conditions and modelled during the operation and closure period. The COPC concentrations in moose, snowshoe hare, and grouse tissue also depended on the animals' consumption rates of these media. The food chain model and results are presented in Appendix A to this SLRA. Table 3.2-1 summarizes the modelled COPC concentration in moose, snowshoe hare, and grouse tissue under baseline, operation and closure scenarios.

3.3 Plant Tissue Concentrations

Leafs of berries (*Vaccinium membranaceum* and *V. ovalifolium*, n=20), raspberries (*Rubus idaeus*, n=2), sitka valerian (*Valeriana sitchensis*, n=23), and willows (*Salix* ssp., n=12), as well as fruit of *Vaccinium* spp. (blueberry, n=6) were collected within and downstream of the proposed Mine site in the summers of 2008/2009 and analyzed for metal concentrations (Table 3.3-1). Raw results of the laboratory analysis are presented in Chapter 17 Terrestrial Ecosystems; and Appendix 17-A, *KSM 2009 Vegetation and Ecosystem Mapping Baseline Report*. For all species and locations, metal concentrations were consistently highest for four key plant mineral nutrients (potassium, phosphorous, calcium, and magnesium; data not shown). Concentrations of heavy metals such as arsenic, chromium, lead, and mercury were very low (many below detection limits) for all species and locations, including near the pits. Berry and leaf data from all species were pooled for use as vegetation input in the food chain model to estimate wildlife tissue concentrations (moose, snowshoe hare, grouse; see Appendix A to this SLRA). The average of the berry data alone was used to calculate the direct exposure to people who consume local berries.

Table 3.2-1. Predicted Metal Concentrations in Terrestrial Wildlife from Exposure to Soil, Surface Water, and Vegetation (mg/kg wet weight)

	Moose			Grouse			Hare		
COPC (Total)	**Baseline**	**Operations**	**Closure**	**Baseline**	**Operations**	**Closure**	**Baseline**	**Operations**	**Closure**
Aluminum	7.1	7.3	7.4	1686	1686	1686	0.165	0.165	0.165
Arsenic	0.0202	0.0206	0.0206	3.83	3.83	3.83	0.000474	0.000474	0.000474
Barium	0.0294	0.0297	0.0298	0.263	0.263	0.263	0.000432	0.000432	0.000432
Beryllium	0.0007	0.0007	0.0007	0.0563	0.0563	0.0563	0.000011	0.000011	0.000011
Cadmium	0.0003	0.0003	0.0003	0.0080	0.0080	0.0080	0.0000033	0.0000033	0.0000033
Chromium	0.0981	0.0990	0.0991	1.56	1.56	1.56	0.00225	0.00225	0.00225
Cobalt	0.0759	0.0767	0.0768	5.90	5.90	5.90	0.00164	0.00164	0.00164
Copper	0.61	0.62	0.63	12.7	12.7	12.7	0.0128	0.0128	0.0128
Lead	0.00164	0.00167	0.00167	1.96	1.96	1.96	0.0000381	0.0000381	0.0000381
Mercury	0.0015	0.0016	0.0016	0.0016	0.0016	0.0016	0.0000315	0.0000315	0.0000315
Molybdenum	0.0081	0.0081	0.0081	0.549	0.549	0.549	0.000172	0.000172	0.000172
Nickel	0.0751	0.08	0.08	0.0041	0.0041	0.0041	0.00149	0.00149	0.00149
Selenium	0.0038	0.0041	0.0041	0.327	0.327	0.327	0.000059	0.000059	0.000059
Silver	0.0011	0.0011	0.0011	0.347	0.347	0.347	0.00003	0.00003	0.00003
Tin	0.122	0.122	0.122	0.472	0.472	0.472	0.00261	0.00261	0.00261
Vanadium	0.0762	0.0695	0.07	0.00371	0.00371	0.00371	0.00160	0.00160	0.00160
Zinc	0.0130	0.0132	0.0132	0.0879	0.0880	0.0880	0.000162	0.000163	0.000163

Table 3.3-1. Total Metal Concentrations Measured in Vegetation and Berry Tissue (mg/kg wet weight, 95% UCLM)

COPC	Vegetation[1] Concentration, 95% UCLM (n = 63)	Berry[2] Concentration, 95% UCLM (n = 6)
Aluminum	19.7	3.99
Arsenic	0.0110	0.00431
Barium	13.7	2.30
Beryllium	0.0397	0.0259
Cadmium	0.234	0.0026
Chromium	0.107	0.043
Cobalt	0.126	0.009
Copper	1.278	1.139
Lead	0.0147	0.009
Mercury	0.00415	0.00021
Molybdenum	0.157	0.237
Nickel	0.377	0.0691
Selenium	0.110	0.0863
Silver	nd	nd
Tin	0.0250	0.0491
Vanadium	0.0591	0.0431
Zinc	12.79	1.77

[1] Vegetation samples represent Vaccinium spp., Rubus ssp., Salix ssp., and Valeriana sitchensis
[2] Berry samples represent blueberry (Vaccinium spp.)

3.4 Human Receptor Characteristics

The human receptor characteristics used to calculate the EDI were: body weight (BW) in kilograms, ingestion rate (IR) in kg-wet weight/day (kg-ww/day), and consumption frequency (number of times consumed per year) of the selected country foods. Consumption frequency was converted to the fraction of the year (f) that the typical country food harvester would consume the food.

Table 3.4-1 presents a summary of the human receptor characteristics. The body weights for adults and toddlers were based on guidance provided by Health Canada (Health Canada 2010a). Receptor characteristics were based on guidance provided by Health Canada (Health Canada 2010a) and country foods interviews conducted by Jin (2006). The ingestion rate and frequency of each country food was assumed to accurately represent the consumption pattern of people who consume the most of each country food from the study area (Table 3.4-1). Data from Jin interviews (2006) were based on adult serving sizes and consumption frequencies. It was assumed that a toddler would eat the country foods at the same frequency as adults. The assumed toddler serving sizes were calculated as 43% of the adult serving sizes as per (Richardson 1997). It is anticipated that this assumption overestimates the actual toddler serving sizes.

Table 3.4-1. Human Receptor Characteristics

Body Weight (BW)	Toddlers 16.5 kg			Adults 70.7 kg		
Country Food	**Ingestion Rate (IR) (kg/day)**	**# Meals per Year**	**Exposure Frequency (F)**	**Ingestion Rate (IR) (kg/day)**	**# Meals per Year**	**Exposure Frequency (F)**
Moose	0.092	364	0.997	0.213	364	0.997
Snowshoe Hare	0.150	3	0.008	0.348	3	0.008
Grouse	0.129	6	0.016	0.299	6	0.016
Fish (Dolly Varden)	0.120	7	0.019	0.279	7	0.019
Berries	0.120	12	0.033	0.280	12	0.033

3.5 Estimated Daily Intake

The EDI of each COPC for toddlers and adults was based on the predicted (moose, snowshoe hare, grouse) and measured (berries) tissue concentrations and the human receptor characteristics.

The following equation was used to estimate the EDI of COPCs from the consumption of country foods:

$$EDI_{food} = \frac{IR \times C_{food} \times F_s}{BW}$$

where:

EDI_{food} = estimated daily intake of COPCs from country food (µg COPC/kg BW/day)
IR = ingestion rate (kg/day)
C_{food} = concentration of COPCs in food (mg/kg)
F_s = fraction of year consuming country food (unitless)
BW = body weight (kg)

The EDI of each COPC for toddler and adult receptors for baseline, operation, and closure scenarios is presented in Table 3.5-1. For this assessment, it was assumed that 100% of the country foods were harvested from areas downstream of the Mine site and that 100% of the COPCs were bioavailable, assumptions that are not entirely possible, and therefore provide a highly conservative estimate. Appendix B to this SLRA presents a sample calculation of the EDI of aluminum for toddlers consuming moose tissue for the baseline scenario.

Table 3.5-1. Estimated Daily Intake of Contaminants of Potential Concern by Human Receptors (mg/kg body weight/day)

COPC	Estimated Daily Intake of COPC (mg/kg BW) by Adult Receptor											
	Baseline				Operations				Closure			
	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries
Aluminum	2.15E-02	**1.17E-01**	6.66E-06	5.20E-04	2.20E-02	**1.17E-01**	6.67E-06	5.20E-04	2.21E-02	**1.17E-01**	6.67E-06	5.20E-04
Arsenic	6.07E-05	**2.66E-04**	1.92E-08	5.62E-07	6.18E-05	**2.66E-04**	1.92E-08	5.62E-07	6.20E-05	**2.66E-04**	1.92E-08	5.62E-07
Barium	8.84E-05	1.83E-05	1.75E-08	**2.99E-04**	8.94E-05	1.83E-05	1.75E-08	**2.99E-04**	8.95E-05	1.83E-05	1.75E-08	**2.99E-04**
Beryllium	2.07E-06	**3.91E-06**	4.53E-10	3.37E-06	2.12E-06	**3.91E-06**	4.53E-10	3.37E-06	2.11E-06	**3.91E-06**	4.53E-10	3.37E-06
Cadmium	**8.70E-07**	5.55E-07	1.33E-10	3.37E-07	**8.80E-07**	5.55E-07	1.33E-10	3.37E-07	**8.80E-07**	5.55E-07	1.33E-10	3.37E-07
Chromium	**2.95E-04**	1.08E-04	9.12E-08	5.62E-06	**2.97E-04**	1.08E-04	9.12E-08	5.62E-06	**2.98E-04**	1.08E-04	9.12E-08	5.62E-06
Cobalt	2.28E-04	**4.10E-04**	6.62E-08	1.12E-06	2.30E-04	**4.10E-04**	6.62E-08	1.12E-06	2.31E-04	**4.10E-04**	6.62E-08	1.12E-06
Copper	**1.83E-03**	8.80E-04	5.19E-07	1.48E-04	**1.88E-03**	8.80E-04	5.19E-07	1.48E-04	**1.88E-03**	8.80E-04	5.19E-07	1.48E-04
Lead	4.93E-06	1.37E-04	1.54E-09	1.12E-06	2.15E-05	5.85E-04	6.61E-09	4.81E-06	2.15E-05	5.85E-04	6.61E-09	4.81E-06
Mercury	**4.64E-06**	1.11E-07	1.27E-09	2.74E-08	**4.66E-06**	1.11E-07	1.27E-09	2.74E-08	**4.66E-06**	1.11E-07	1.27E-09	2.74E-08
Molybdenum	2.44E-05	**3.82E-05**	6.96E-09	3.08E-05	2.45E-05	**3.82E-05**	6.96E-09	3.08E-05	2.44E-05	**3.82E-05**	6.96E-09	3.08E-05
Nickel	**2.26E-04**	2.86E-07	6.03E-08	9.00E-06	**2.28E-04**	2.86E-07	6.03E-08	9.00E-06	**2.29E-04**	2.86E-07	6.03E-08	9.00E-06
Selenium	1.16E-05	**2.27E-05**	2.38E-09	1.12E-05	1.23E-05	**2.27E-05**	2.38E-09	1.12E-05	1.22E-05	**2.27E-05**	2.38E-09	1.12E-05
Silver	3.35E-06	**2.42E-05**	1.08E-09	nd	3.39E-06	**2.42E-05**	1.08E-09	nd	3.40E-06	**2.42E-05**	1.08E-09	nd
Tin	**3.67E-04**	3.28E-05	1.06E-07	6.39E-06	**3.67E-04**	3.28E-05	1.06E-07	6.39E-06	**3.67E-04**	3.28E-05	1.06E-07	6.39E-06
Vanadium	**2.29E-04**	2.58E-07	6.47E-08	5.62E-06	**2.09E-04**	2.58E-07	6.45E-08	5.62E-06	**2.09E-04**	2.58E-07	6.45E-08	5.62E-06
Zinc	3.91E-05	6.11E-06	6.57E-09	**2.31E-04**	3.97E-05	6.12E-06	6.58E-09	**2.31E-04**	3.98E-05	6.12E-06	6.58E-09	**2.31E-04**

COPC	Estimated Daily Intake of COPC (mg/kg BW) by Toddler Receptor											
	Baseline				Operations				Closure			
	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries
Aluminum	3.96E-02	**2.16E-01**	1.23E-05	9.58E-04	4.06E-02	**2.16E-01**	1.23E-05	9.58E-04	4.07E-02	**2.16E-01**	1.23E-05	9.58E-04
Arsenic	1.12E-04	**4.91E-04**	3.53E-08	1.03E-06	1.14E-04	**4.91E-04**	3.53E-08	1.03E-06	1.14E-04	**4.91E-04**	3.54E-08	1.03E-06
Barium	1.63E-04	3.37E-05	3.22E-08	**5.51E-04**	1.65E-04	3.37E-05	3.22E-08	**5.51E-04**	1.65E-04	3.37E-05	3.22E-08	**5.51E-04**
Beryllium	3.81E-06	**7.21E-06**	8.35E-10	6.21E-06	3.90E-06	**7.21E-06**	8.35E-10	6.21E-06	3.90E-06	**7.21E-06**	8.35E-10	6.21E-06
Cadmium	**1.60E-06**	1.02E-06	2.46E-10	6.21E-07	**1.62E-06**	1.02E-06	2.46E-10	6.21E-07	**1.62E-06**	1.02E-06	2.46E-10	6.21E-07
Chromium	**5.43E-04**	2.00E-04	1.68E-07	1.03E-05	**5.48E-04**	2.00E-04	1.68E-07	1.03E-05	**5.49E-04**	2.00E-04	1.68E-07	1.03E-05
Cobalt	4.20E-04	**7.56E-04**	1.22E-07	2.07E-06	4.25E-04	**7.56E-04**	1.22E-07	2.07E-06	4.25E-04	**7.56E-04**	1.22E-07	2.07E-06
Copper	**3.38E-03**	1.62E-03	9.55E-07	2.73E-04	**3.46E-03**	1.62E-03	9.56E-07	2.73E-04	**3.47E-03**	1.62E-03	9.56E-07	2.73E-04
Lead	9.09E-06	2.52E-04	2.84E-09	2.07E-06	9.23E-06	2.52E-04	2.84E-09	2.07E-06	9.25E-06	2.52E-04	2.84E-09	2.07E-06
Mercury	**8.56E-06**	2.05E-07	2.35E-09	5.05E-08	**8.59E-06**	2.05E-07	2.35E-09	5.05E-08	**8.59E-06**	2.05E-07	2.35E-09	5.05E-08
Molybdenum	4.49E-05	**7.04E-05**	1.28E-08	5.67E-05	4.51E-05	**7.04E-05**	1.28E-08	5.67E-05	4.50E-05	**7.04E-05**	1.28E-08	5.67E-05
Nickel	**4.16E-04**	5.27E-07	1.11E-07	1.66E-05	**4.21E-04**	5.27E-07	1.11E-07	1.66E-05	**4.22E-04**	5.27E-07	1.11E-07	1.66E-05
Selenium	2.13E-05	**4.19E-05**	4.37E-09	2.07E-05	2.26E-05	**4.19E-05**	4.38E-09	2.07E-05	2.26E-05	**4.19E-05**	4.38E-09	2.07E-05
Silver	6.18E-06	**4.45E-05**	1.99E-09	nd	6.25E-06	**4.45E-05**	1.99E-09	nd	6.26E-06	**4.45E-05**	1.99E-09	nd
Tin	**6.76E-04**	6.04E-05	1.95E-07	1.18E-05	**6.76E-04**	6.04E-05	1.95E-07	1.18E-05	**6.76E-04**	6.04E-05	1.95E-07	1.18E-05
Vanadium	**4.22E-04**	4.75E-07	1.19E-07	1.03E-05	**3.85E-04**	4.75E-07	1.19E-07	1.03E-05	**3.86E-04**	4.75E-07	1.19E-07	1.03E-05
Zinc	7.20E-05	1.13E-05	1.21E-08	**4.26E-04**	7.32E-05	1.13E-05	1.21E-08	**4.26E-04**	7.33E-05	1.13E-05	1.21E-08	**4.26E-04**

nd - Not determined

Highlighted numbers denote country food with highest estimated daily intake for a toddler or adult of a particular COPC.

4 Toxicity Reference Values

4.1 Introduction

The TRV assessment involves determining the amount of COPCs that can be taken into the human body without experiencing adverse health effects. TRVs are safe levels below which there is minimal risk of adverse health effects. The TRVs used in the country foods assessment were obtained from Health Canada (Health Canada 2010b). The TRVs were derived by Health Canada's Bureau of Chemical Safety, Chemical Health Hazard Division or were adopted by the division from various other regulatory agencies including the US Environmental Protection Agency's (US EPA) Integrated Risk Information System (IRIS), and the Food and Agriculture Organization of the United Nations and World Health Organization Joint Expert Committee on Food Additives (JECFA). Additional TRVs were obtained from the US EPA and the Agency for Toxic Substances and Disease Registry (ATSDR).

The TRVs in this assessment are presented as TDIs or Provisional Tolerable Daily Intakes (PTDIs). The TDI is defined as the amount of metal per unit body weight that can be taken into the body each day (mg/kg BW/day) with no risk of adverse health effects. The term "tolerable" is used because it signifies permissibility rather than acceptability for the intake of contaminants unavoidably associated with the consumption of otherwise wholesome and nutritious (country) foods (Herrman and Younes 1999). Use of the term "provisional" expresses the tentative nature of the evaluation, in view of the paucity of reliable data on the consequences of human exposure at levels approaching those indicated. The TDIs used in this baseline assessment are presented in Table 4.1-1. It is noted that the US EPA uses the term Reference Dose (RfD) rather than TDI, but for consistency within the report, RfDs will be reported as TDIs. Toxicity studies on which the TDIs were based and the rationale for their selection are briefly summarized in Section 5.2. Health Canada guidelines were used preferentially unless they were not available for certain COPCs, in which case US EPA guidelines were used.

Table 4.1-1. Toxicity Reference Values for Contaminants of Potential Concern

	TRV (mg/kg BW/d)	
Metals	**Adult**	**Toddler**
Aluminum	1[a]	1[a]
Arsenic	0.0003	0.0003
Barium	0.2	0.2
Beryllium	0.002[b]	0.002[b]
Cadmium	0.0010	0.0010
Chromium	0.001	0.001
Cobalt	0.001[a]	0.001[a]
Copper	0.141	0.091
Lead	0.0036	0.0036
Mercury	0.0003	0.0003

(continued)

Table 4.1-1. Toxicity Reference Values for Contaminants of Potential Concern (completed)

	TRV (mg/kg BW/d)	
Metals	**Adult**	**Toddler**
Molybdenum	28	23
Nickel	0.011	0.011
Selenium	0.0057	0.62
Silver	0.005[a]	0.005[a]
Tin	0.6[c]	0.6[c]
Vanadium	0.009[b]	0.009[b]
Zinc	0.57	0.48

[a] Toxicological Profile For Aluminum. U.S. Department of Health and Human Services. Public Health Services. Agency for Toxic Substances and Disease Registry (ATSDR 2008).
[b] Integrated Risk Information System. Online: www.epa.gov/iri s (US EPA 2012)
[c] Toxicological Profile For Cobalt. U.S. Department of Health and Human Services. Public Health Services. Agency for Toxic Substances and Disease Registry (ATSDR 2004)
All others from Health Canada (2010b)

4.2 Toxicity Reference Values

4.2.1 Aluminum

Neither the US EPA or Health Canada have derived an RfD or TDI for aluminum. The JECFA provides an estimate for a provisional tolerable weekly intake of 7 mg/kg BW. ATSDR has derived an intermediate-duration and a chronic-duration oral minimal risk level (MRL) of 1 mg Al/kg/day for aluminum (ATSDR 2008). The chronic-duration MRL is based on a lowest observable adverse effects level (LOAEL) of 100 mg Al/kg/day for neurological effects in mice exposed to aluminum lactate in the diet during gestation, lactation, and postnatally until two years of age (Golub et al. 2000).The MRL was derived by dividing the LOAEL by an uncertainty factor of 300 (3 for the use of a minimal LOAEL, 10 for animal to human extrapolation, and 10 for human variability) and a modifying factor of 0.3 to account for the higher bioavailability of the aluminum lactate used in the principal study compared to the bioavailability of aluminum in the human diet and drinking water. A TDI of 1 mg/kg BW/day is used in this assessment.

4.2.2 Arsenic

For assessment of non-cancer risks from arsenic, IRIS (US EPA 2012) provides 0.3 µg/kg BW/day for a chronic oral RfD, while JECFA recommends a TDI of 1 µg/kg BW/day for oral exposures.

Arsenic is the only metal in this study that is considered carcinogenic via the ingestion pathway. For carcinogens, slope factors are used as the TRVs (Health Canada 2010b). A slope factor is the upper bound estimate of the probability of a response-per-unit intake of a material of concern over an average human lifetime. It is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of arsenic. Upper-bound estimates conservatively exaggerate the risk to ensure that the risk is not underestimated if the underlying model is incorrect. The oral slope factor for arsenic cancer risk is 1.8 per mg/kg BW/day (Health Canada 2010b), based on the tumourigenic dose (TD_{05}). Of the various species of arsenic that exist, inorganic arsenic salts have been identified as the most toxic forms, while organic arsenic compounds have lower toxicity, but a higher bioaccumulation potential (Roy and Saha 2002). Total arsenic in food consists of organic as well as inorganic arsenic species (Lasky et al. 2004).

4.2.3 Barium

Health Canada (Health Canada 2010b) based an oral TDI for barium on the US EPA value of 0.2 mg/kg BW/day. A benchmark dose (BMD) lower limit with an incidence of 5% induced lesions of 63 mg/kg BW/day in rats and mice was divided by an uncertainty factor of 300 (10 for animal to human extrapolation, 10 for human variability, 3 for database deficiencies).

4.2.4 Beryllium

US EPA's Integrated Risk Information System provides an oral RfD of 0.002 mg/kg BW/day based on a BMD_{10} of 0.46 mg/kg BW/day in a chronic feeding study using dogs (Morgareidge, Cox, and Gallo 1976) with an uncertainty factor of 300. No human information on the oral toxicity of this compound was located. Further uncertainty is the lack of chronic oral studies establishing LOAELs and examining other endpoints, but it is thought that the uncertainty factor compensates for areas of scientific uncertainty.

4.2.5 Cadmium

Health Canada (Health Canada 2010b) provides a TDI of 0.8 µg/kg BW/day, which is used in this assessment. This TDI is similar to JECFA's PTMI of 25 µg/kg BW/month (JECFA 2005), which accounts for the long half-life of cadmium in the body. The TDI of 0.8 µg/kg BW/day will ensure cadmium concentrations in the renal cortex do not exceed 50 mg/kg; this level is thought to protect normal kidney function. Health Canada and IRIS (Health Canada 2010b; US EPA 2012) provide a TDI of 1 µg/kg BW/day for oral exposures to cadmium based on recommendations by the JECFA (JECFA 1972, 2005).

4.2.6 Chromium

Health Canada provides a TDI of 0.001 mg/kg BW/day for total chromium (Health Canada 2010b). The TDI for total chromium was selected for use because hexavalent chromium is generally not present in animal or plant tissue. After its absorption, hexavalent chromium is rapidly reduced to the trivalent form that is the main form found in biological material (Leonard and Lauwerys 1980; Kerger et al. 1996; Shrivastava, Upreti, and Chaturvedi 2003). The TDI for chromium is based on the IRIS RfD, which was derived from a chronic toxicity study conducted by (Ivankovic and Preussman 1975). Groups of rats (12 to 19 per group) were exposed to 0%, 2%, or 5% chromic oxide in bread for five days per week over 18 weeks and monitored for food consumption and body weight. Toxicological endpoints (measures of effect) included serum protein, urine analysis, organ weights, and microscopic examination. The only effects observed were reductions in liver (12%) and spleen (37%) weights of animals in the high-dose group. The no observable adverse effects level (NOAEL) was 1,468 mg/kg BW/day. An uncertainty factor of 1,000 was applied to the NOAEL: 10 for interspecies extrapolation, 10 for protection of the most susceptible receptor, and 10 for a lack of chronic and reproductive toxicity studies (US EPA 2012).

4.2.7 Cobalt

Oral exposure to elevated levels of cobalt results in a range of immunological, neurological, cardiac, and respiratory effects. The EPA has not derived a reference concentration or reference dose (RfD) for cobalt and compounds. Similarly, no cancer classification has been performed by the EPA. ATSDR derived an MRL of 0.01 mg/kg BW/day for intermediate-duration oral exposure, based on a LOAEL of 1 mg/kg BW/day for polycythemia in human volunteers (Davis and Fields 1958). No other inhalation or oral MRLs were derived.

4.2.8 Copper

Health Canada (2010b) reports a TDI of 91 to 141 µg/kg BW/day for copper based on specific age groups. Copper is an essential nutrient. JECFA recommends a provisional value of maximum tolerable daily intake of 500 µg/kg BW. However, recommendations were made for further collection of information on copper with considerations of epidemiological surveys to study the evidence of copper-induced ill-health. A TDI of 91 µg/kg BW/day and 141 µg/kg BW/day was used for toddlers and adults, respectively, in this report.

4.2.9 Lead

Health Canada is currently reviewing a TDI for lead (Health Canada 2010b). Previously, a provisional TDI of 3.6 µg/kg BW/day for lead based on the PTWI of 25 µg/kg BW/day recommended by the JECFA (JECFA 2000) was provided. However, JECFA withdrew this PTWI in 2011 (JECFA 2011) because the intake value was associated with a decrease of at least 3 Intelligence Quotient points in children and an increase in systolic blood pressure of approximately 3 mmHg (0.4 kPa) in adults. Because the dose-response analysis done by JECFA does not provide any indication of a threshold for the key effects of lead, the Committee concluded that it was not possible to establish a new PTWI that would be considered to be health protective. Until evaluation by Health Canada, the currently established TDI of 3.6 µg/kg BW/day was used for this assessment.

4.2.10 Mercury

Health Canada provides a PTDI of 0.3 µg/kg BW/day for inorganic mercury exposure for the general public, based on CCME soil quality guidelines and supporting documentation on health-based guidelines (Health Canada 2010b). The Health Canada Bureau of Chemical Safety, Chemical Health Hazard Division guideline of 0.71 µg/kg BW/day (Health Canada 2010b) is based on previous JECFA evaluations of a PTWI of 5 µg/kg BW/week (0.71 µg/kg BW/day) for total mercury, established at the sixteenth JECFA meeting, which was withdrawn in 2011 and replaced with a PTWI of 3.3 µg/kg BW/week (0.47 µg/kg BW/day; JECFA 2011). Therefore, the more conservative and current value of 0.3 µg/kg BW/day is used.

For methylmercury, JECFA recommends a PTDI of 0.47 µg/kg BW/day for the general public, and 0.23 µg/kg BW/day for sensitive groups (e.g., children and women who are pregnant or who are of child-bearing age). This was also adopted by Health Canada (Health Canada 2010b).

For fish, mercury was assumed to be present 100% as methylmercury (Health Canada 2007). As data are not readily available on the mercury species present in the local vegetation and terrestrial animals, mercury was assumed to be in tissues in a mixture of organic and inorganic forms. Therefore, for moose, snowshoe hare, grouse and plant tissues, mercury was compared to the Health Canada (Health Canada 2010b) total mercury PTDI as a toxicity reference value.

4.2.11 Molybdenum

Molybdenum is an essential element and required for human nutrition. Health Canada provides an age- and body weight-adjusted tolerable upper limit for molybdenum that was based on a NOAEL of 0.9 mg/kg BW/day and a LOAEL of 1.6 mg/kg/day for reproductive effects in rats, with an uncertainty factor of 30 (Health Canada 2010b).

4.2.12 Nickel

Health Canada provides a TDI of 25 μg/kg BW/day for nickel (Health Canada 2010b). The TDI for total nickel (as soluble salts) was based on a dietary study in rats that found a NOAEL of 5,000 μg/kg BW/day for altered organ to body weight ratios. An uncertainty factor of 200 was applied to the NOAEL: 10 for interspecies variation and 10 to protect sensitive populations. A modifying factor of two was also applied to account for the inadequacies of the reproductive studies.

4.2.13 Selenium

Selenium is an essential element and required for human nutrition. Health Canada provides an age- and body weight-adjusted tolerable upper limit for selenium of 0.0057-0.0062 mg/person/day for adults and toddlers, respectively. (Health Canada 2010b). This was based on a NOAEL in adults of 0.8 mg/kg BW/day in a cohort study (Yang and Zhou 1994), and a NOAEL in children of 700 mg/kg BW/day (Shearer and Hadjimarkos 1975). Health effects due to an exposure to elevated levels of selenium are described as selenosis (gastrointestinal disorders, hair loss, sloughing of nails, fatigue, irritability, and neurological damage).

4.2.14 Silver

US EPA's IRIS provides an oral RfD of 0.005 mg/kg BW/day based on a LOAEL of 0.014 mg/kg BW/day from a study in humans (Gaul and Staud 1935). An uncertainty factor of 3 was applied to account for minimal effects in a subpopulation that has exhibited an increased propensity for the development of argyria. Argyria is the critical effect in humans ingesting silver, a medically benign, but permanent and photo-sensitive bluish-gray discoloration of the skin. Silver compounds have been employed for medical uses for centuries.

4.2.15 Tin

The subchronic oral RfD for tin was obtained from the Health Effects Assessment Summary Tables (US EPA 1972) and was based on a NOAEL in rats of 2,000 mg/kg for kidney lesions. It was calculated by analogy to stannous chloride by correcting for differences in molecular weight and application of an uncertainty factor of 100 and was provided as 0.6 mg/kg BW/day. ATSDR lists a similar oral minimal risk level of 0.3 mg/kg BW/day for inorganic tin and compounds.

4.2.16 Vanadium

US EPA's IRIS provides an oral RfD of 0.009 mg/kg BW/day based on a lower dose level (17.9 mg/kg vanadium pentoxide; Stokinger et al. 1953). In this chronic study, an unspecified number of rats were exposed to dietary levels of 10 or 100 mg/kg vanadium (about 17.9 or 179 mg/kg vanadium pentoxide) for 2.5 years. The criteria used to evaluate vanadium toxicity were growth rate, survival, and hair cystine content. The only significant change reported was a decrease in the amount of cystine in the hair of animals ingesting vanadium.

4.2.17 Zinc

Health Canada provides a TDI of 700 µg/kg BW/day(Health Canada 2010b). This value was based on the Upper Safe Level established by the Expert Group on Vitamins and Minerals (FSA 2003). A LOAEL of 50 mg/day was found for both men and women exposed to zinc supplements (i.e., additional zinc exposure besides that incurred through normal food and water intake). The LOAEL was converted to a NOAEL by dividing it by an uncertainty factor of two to give a NOAEL of 25 mg/day, which is 420 µg/kg BW/day in a 60 kg person. Thus, the Upper Safe Level for zinc supplements is 420 µg/kg BW/day. If the maximum zinc intake of 17 mg/day (280 µg/kg BW/day) from food is added to the Upper Safe Level, the maximum total intake for zinc is equivalent to 700 µg/kg BW/day.

5 Risk Characterization

5.1 Introduction

Using the results of the exposure assessment and TRV assessment, potential adverse human health effects from the consumption of country foods were estimated using the exposure ratio approach. For carcinogenic chemicals, risks are calculated as incremental lifetime cancer risk (ILCR), over and above background cancer risks. In addition, the RMWIs were calculated for each country food evaluated. These RMWIs were compared to current weekly consumption rates of the country foods.

5.2 Estimation of Potential for Non-carcinogenic Adverse Effects

Potential adverse human health effects were estimated using exposure ratios (ER), and were calculated as:

$$\textit{Exposure Ratio (ER)} = \frac{\textit{estimated daily intake (EDI)}}{\textit{tolerable daily intake (TDI)}}$$

For the purpose of an SLRA for non-carcinogenic COPCs in foods, Health Canada indicated that an exposure ratio of 0.2 is the maximum acceptable exposure that will not be associated with health risks (Health Canada 2010a). Due to the conservative estimate, ER values greater than 0.2 do not necessarily indicate that adverse health effects will occur since the TRVs are conservative and protect human health based on the application of uncertainty factors. However, it does suggest potential risks which may require a more detailed evaluation.

Table 5.2-1 presents the calculated ERs based on the predicted wildlife concentrations and measured berries concentrations. For snowshoe hare and berries, all ERs were below 0.2 for baseline conditions, operation, and closure. Thus, the estimation of risk based on the predicted and measured metal tissue concentrations is acceptable for all human life stages and all metals evaluated for these three country foods. The ER values for moose and grouse were below 0.2 for all the metals of concern, except arsenic, chromium, and cobalt (range: 0.202-1.64) for adults and toddlers for all three scenarios evaluated. The ER for aluminum for toddlers was also slightly above 0.2 (0.216) for baseline conditions, operation, and closure.

5.3 Estimation of Cancer Risks

For carcinogenic chemicals, risks are calculated as ILCR, which represents the increased risk of an individual developing cancer over her lifetime attributable to the exposure to the metal through the examined exposure pathway. Of the metals evaluated, only arsenic is considered carcinogenic through ingestion. Arsenic is often associated with gold deposits. Carcinogenic risks were estimated as ILCR estimates according to the following formula (Health Canada 2010a):

$$\textit{ILCR} = \textit{Estimated lifetime daily exposure (mg/kg BW/day) x Oral cancer slope factor } (\textit{mg/kg BW/day})^{-1}$$

For the estimated lifetime daily exposure, measured and predicted total arsenic concentrations in tissue were used in the exposure calculations. Appendix C provides a sample calculation for the estimated lifetime daily exposure. The oral slope factor for arsenic cancer risk is 1.8 per mg/kg BW/day (Health Canada 2010b). An ILCR estimate that is less than 1×10^{-5} is normally considered acceptable. The results of the ILCRs from exposure to arsenic in country foods are presented in Table 5.3-1. The calculated ILCRs for arsenic from snowshoe hare and berries were less than 1×10^{-5} and can be considered safe for consumption at the current local consumption rates. The consumption rates for moose and grouse used in this assessment appear to be associated with a higher incremental lifetime cancer risk (ranges from $1.1\text{x}10^{-4}$ to 5.8×10^{-4}). Although the Province of British Columbia accepts an ILCR of 1 in 100,000 (10^{-5}), many agencies and provinces, including the US EPA, identify a range of increased cancer incidence risks; generally, from 1 in 10,000 (or 1×10^{-4}) to 1 in 1,000,000 (or 1×10^{-6}) is considered an acceptable risk range, depending on the situation and circumstances of exposure (Health Canada 2010a).

In this assessment, total arsenic concentrations were used to estimate the ILCR. However, arsenic in tissues consists of organic and inorganic arsenic species. Of the various species of arsenic that exist, inorganic arsenic salts have been identified as the most toxic forms, while organic arsenic compounds have lower toxicity, but a higher bioaccumulation potential (Roy and Saha 2002). For instance, the proportion of inorganic and organic arsenic in chicken was estimated to be 0.65 and 0.35, respectively (Lasky et al. 2004). Therefore, the estimation of the ILCR from total arsenic is a conservative over-estimation of potential incremental risks.

All three exposure scenarios (baseline, operation, closure) have similar ILCRs associated with them, indicating that potential Project effects will not increase the ILCR from the consumption of country foods. The exceedance of $1\text{x } 10^{-5}$ indicates that the data and assumptions used to estimate the risks in this SLRA should be more closely examined. Uncertainties associated with this risk estimate are discussed in Section 7, Uncertainties, of this SLRA.

5.4 Recommended Maximum Weekly Intakes

The RMWIs were calculated as described by Health Canada (2010a), using the following equation:

$$RMWI = \frac{TRV \text{ x } BW \text{ x } 7}{C_{food}}$$

where:

RMWI = recommended maximum weekly intake of food (g/week)
TRV = toxicological reference value (µg/kg BW per day)
BW = receptor body weight (kg)
7 = days/week
C_{food} = metal concentration in food (µg/g)

Table 5.2-1. Exposure Ratios for Human Receptors

COPC	Exposure Ratio for Adult Receptor											
	Baseline				Operations				Closure			
	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries
Aluminum	2.15E-02	1.17E-01	6.66E-06	5.20E-04	2.20E-02	1.17E-01	6.67E-06	5.20E-04	2.21E-02	1.17E-01	6.67E-06	5.20E-04
Arsenic	**2.02E-01**	**8.87E-01**	6.39E-05	1.87E-03	**2.06E-01**	**8.87E-01**	6.40E-05	1.87E-03	**2.07E-01**	**8.87E-01**	6.40E-05	1.87E-03
Barium	4.42E-04	9.14E-05	8.73E-08	1.50E-03	4.47E-04	9.14E-05	8.74E-08	1.50E-03	4.47E-04	9.14E-05	8.74E-08	1.50E-03
Beryllium	1.03E-03	1.96E-03	2.27E-07	1.68E-03	1.06E-03	1.96E-03	2.27E-07	1.68E-03	1.06E-03	1.96E-03	2.27E-07	1.68E-03
Cadmium	8.70E-04	5.55E-04	1.33E-07	3.37E-04	8.80E-04	5.55E-04	1.33E-07	3.37E-04	8.80E-04	5.55E-04	1.33E-07	3.37E-04
Chromium	**2.95E-01**	1.08E-01	9.12E-05	5.62E-03	**2.97E-01**	1.08E-01	9.12E-05	5.62E-03	**2.98E-01**	1.08E-01	9.12E-05	5.62E-03
Cobalt	**2.28E-01**	**4.10E-01**	6.62E-05	1.12E-03	**2.30E-01**	**4.10E-01**	6.62E-05	1.12E-03	**2.31E-01**	**4.10E-01**	6.62E-05	1.12E-03
Copper	1.30E-02	6.24E-03	3.68E-06	1.05E-03	1.33E-02	6.24E-03	3.68E-06	1.05E-03	1.34E-02	6.24E-03	3.68E-06	1.05E-03
Mercury	1.55E-02	3.71E-04	4.25E-06	9.14E-05	1.55E-02	3.71E-04	4.25E-06	9.14E-05	1.55E-02	3.71E-04	4.25E-06	9.14E-05
Molybdenum	8.71E-07	1.36E-06	2.48E-10	1.10E-06	8.74E-07	1.36E-06	2.48E-10	1.10E-06	8.73E-07	1.36E-06	2.48E-10	1.10E-06
Nickel	2.05E-02	2.60E-05	5.48E-06	8.18E-04	2.08E-02	2.60E-05	5.48E-06	8.18E-04	2.08E-02	2.60E-05	5.48E-06	8.18E-04
Selenium	2.03E-03	3.99E-03	4.17E-07	1.97E-03	2.15E-03	3.99E-03	4.18E-07	1.97E-03	2.15E-03	3.99E-03	4.18E-07	1.97E-03
Silver	6.71E-04	4.83E-03	2.16E-07	nd	6.79E-04	4.83E-03	2.16E-07	nd	6.79E-04	4.83E-03	2.16E-07	nd
Tin	6.12E-04	5.46E-05	1.76E-07	1.07E-05	6.12E-04	5.46E-05	1.76E-07	1.07E-05	6.12E-04	5.46E-05	1.76E-07	1.07E-05
Vanadium	2.54E-02	2.86E-05	7.19E-06	6.24E-04	2.32E-02	2.86E-05	7.17E-06	6.24E-04	2.33E-02	2.86E-05	7.17E-06	6.24E-04
Zinc	6.86E-05	1.07E-05	1.15E-08	4.05E-04	6.97E-05	1.07E-05	1.15E-08	4.05E-04	6.97E-05	1.07E-05	1.15E-08	4.05E-04

COPC	Exposure Ratio for Toddler Receptor											
	Baseline				Operations				Closure			
	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries
Aluminum	3.96E-02	**2.16E-01**	1.23E-05	9.58E-04	4.06E-02	**2.16E-01**	1.23E-05	9.58E-04	4.07E-02	**2.16E-01**	1.23E-05	9.58E-04
Arsenic	**3.73E-01**	**1.64E+00**	1.18E-04	3.45E-03	**3.80E-01**	**1.64E+00**	1.18E-04	3.45E-03	**3.81E-01**	**1.64E+00**	1.18E-04	3.45E-03
Barium	8.14E-04	1.68E-04	1.61E-07	2.76E-03	8.23E-04	1.68E-04	1.61E-07	2.76E-03	8.25E-04	1.68E-04	1.61E-07	2.76E-03
Beryllium	1.91E-03	3.60E-03	4.17E-07	3.10E-03	1.95E-03	3.60E-03	4.18E-07	3.10E-03	1.95E-03	3.60E-03	4.18E-07	3.10E-03
Cadmium	1.60E-03	1.02E-03	2.46E-07	6.21E-04	1.62E-03	1.02E-03	2.46E-07	6.21E-04	1.62E-03	1.02E-03	2.46E-07	6.21E-04
Chromium	**5.43E-01**	2.00E-01	1.68E-04	1.03E-02	**5.48E-01**	2.00E-01	1.68E-04	1.03E-02	**5.49E-01**	2.00E-01	1.68E-04	1.03E-02
Cobalt	**4.20E-01**	**7.56E-01**	1.22E-04	2.07E-03	**4.25E-01**	**7.56E-01**	1.22E-04	2.07E-03	**4.25E-01**	**7.56E-01**	1.22E-04	2.07E-03
Copper	3.71E-02	1.78E-02	1.05E-05	3.00E-03	3.80E-02	1.78E-02	1.05E-05	3.00E-03	3.82E-02	1.78E-02	1.05E-05	3.00E-03
Mercury	2.85E-02	6.84E-04	7.82E-06	1.68E-04	2.86E-02	6.84E-04	7.83E-06	1.68E-04	2.86E-02	6.84E-04	7.83E-06	1.68E-04
Molybdenum	1.95E-06	3.06E-06	5.57E-10	2.47E-06	1.96E-06	3.06E-06	5.57E-10	2.47E-06	1.96E-06	3.06E-06	5.57E-10	2.47E-06
Nickel	3.78E-02	4.79E-05	1.01E-05	1.51E-03	3.83E-02	4.79E-05	1.01E-05	1.51E-03	3.83E-02	4.79E-05	1.01E-05	1.51E-03
Selenium	3.43E-03	6.75E-03	7.06E-07	3.34E-03	3.65E-03	6.76E-03	7.07E-07	3.34E-03	3.64E-03	6.76E-03	7.07E-07	3.34E-03
Silver	1.24E-03	8.90E-03	3.97E-07	nd	1.25E-03	8.90E-03	3.97E-07	nd	1.25E-03	8.90E-03	3.97E-07	nd
Tin	1.13E-03	1.01E-04	3.25E-07	1.96E-05	1.13E-03	1.01E-04	3.25E-07	1.96E-05	1.13E-03	1.01E-04	3.25E-07	1.96E-05
Vanadium	4.69E-02	5.28E-05	1.32E-05	1.15E-03	4.28E-02	5.28E-05	1.32E-05	1.15E-03	4.29E-02	5.28E-05	1.32E-05	1.15E-03
Zinc	1.50E-04	2.35E-05	2.52E-08	8.87E-04	1.52E-04	2.35E-05	2.52E-08	8.87E-04	1.53E-04	2.35E-05	2.52E-08	8.87E-04

nd - Not determined

Highlighted and bolded numbers denote country food with an exposure ration larger than 0.2 for a particular COPC

Table 5.3-1. Estimated Daily Lifetime Exposure and Incremental Lifetime Cancer Risk for Human Receptors Exposed to Arsenic in Country Foods

Country Food	Baseline		Operations		Closure	
	ELDE mg/kg/day	ILCR unitless	ELDE mg/kg/day	ILCR unitless	ELDE mg/kg/day	ILCR unitless
Moose	6.07E-05	**1.09E-04**	7.46E-05	**1.34E-04**	7.47E-05	**1.34E-04**
Grouse	2.66E-04	**4.79E-04**	3.23E-04	**5.82E-04**	3.23E-04	**5.82E-04**
Hare	1.92E-08	3.45E-08	2.33E-08	4.19E-08	2.33E-08	4.19E-08
Berries	5.62E-07	1.01E-06	6.82E-07	1.23E-06	6.82E-07	1.23E-06

Highlighted and bolded numbers indicate elevated incremental lifetime cancer risk.

This equation was applied to each metal and receptor scenario. The metal that had the lowest RMWI for each receptor was selected as the overall RMWI for each country food (Appendix D) because it is the driver of the lowest risk. By using the lowest RMWI for each food type, it is protective for all metals in that particular food. Table 5.4-1 presents the RMWIs as servings per week for all three scenarios. The RMWI has been also converted to the recommended maximum number of servings per week of moose, snowshoe hare, grouse, and berries by dividing the RMWI by the serving size (Jin 2006). The RMWIs and recommended number of servings for the operation and closure scenarios are highly similar to those of the baseline scenario. This is largely due to the relatively small water quality effect compared to baseline that modelled Mine Site-related COPCs will have on the Unuk River habitat. People are assumed to only collect berries outside of the Mine Site, because access is restricted and therefore the RMWI for berries does not change.

Table 5.4-1. Recommended Maximum Weekly Number of Servings of Country Food

Human Receptor	Country Food	Scenario	RMW Intake kg/week	Serving Size kg	RMW # of Servings	Current Weekly # of Servings[1]
Adult	Moose	Baseline	5.05	0.213	23.7	7.0
		Operations	5.00	0.213	23.5	7.0
		Closure	4.99	0.213	23.4	7.0
	Grouse	Baseline	0.04	0.299	0.13	0.12
		Operations	0.04	0.299	0.13	0.12
		Closure	0.04	0.299	0.13	0.12
	Hare	Baseline	219.6	0.348	631.1	0.1
		Operations	219.6	0.348	631.0	0.1
		Closure	219.6	0.348	631.0	0.1
	Berries	Baseline	11.47	0.28	41.0	0.2
		Operations	11.47	0.28	41.0	0.2
		Closure	11.47	0.28	41.0	0.2

(continued)

Table 5.4-1. Recommended Maximum Weekly Number of Servings of Country Food (completed)

Human Receptor	Country Food	Scenario	RMW Intake kg/week	Serving Size kg	RMW # of Servings	Current Weekly # of Servings[1]
Toddler	Moose	Baseline	1.18	0.0916	12.9	7.0
		Operations	1.17	0.0916	12.7	7.0
		Closure	1.17	0.0916	12.7	7.0
	Grouse	Baseline	0.01	0.1286	0.07	0.12
		Operations	0.01	0.1286	0.07	0.12
		Closure	0.01	0.1286	0.07	0.12
	Hare	Baseline	51.3	0.1496	342.6	0.1
		Operations	51.2	0.1496	342.6	0.1
		Closure	51.2	0.1496	342.6	0.1
	Berries	Baseline	2.68	0.1204	22.2	0.2
		Operations	2.68	0.1204	22.2	0.2
		Closure	2.68	0.1204	22.2	0.2

RMW - Recommended Maximum Weekly
[1] based on annual averages

Under all three scenarios, the RMWIs are greater than the current weekly number of servings of moose, snowshoe hare, and berries reported by the country food harvesters. The RMWI for grouse is similar to the current weekly number of servings. Thus, upon mine development and operation the country foods harvesters can continue to consume moose, snowshoe hare, grouse, and berries at rates and frequencies to which they are accustomed.

6 Uncertainty Analysis

6.1 Introduction

The process of evaluating human health risks from exposure to country foods involves multiple steps, each containing inherent uncertainties that ultimately affect the final risk estimates. For the baseline scenarios, these uncertainties exist in numerous areas, including the collection of samples, laboratory analysis, estimation of potential exposures, derivation of toxicity reference values, and food chain model assumptions. For the operation and closure scenarios, the main uncertainties include the modelled water and sediment COPC concentrations, and again the food chain model assumptions. However, for the present SLRA, where uncertainties existed, an appropriate conservative approach was taken to overestimate rather than underestimate potential risks.

Some of the uncertainties associated with the SLRA have been described in detail in Chapter 25; and Appendix 25-A, *KSM Project 2009 Country Foods Baseline Report* (Rescan 2010), and others have been mentioned in the preceding SLRA report sections. The following uncertainty analysis is a qualitative discussion of the key sources of uncertainty during the operation and closure scenarios. There may be sources of uncertainty other than those evaluated here; however, their effect on the estimated risks and RMWIs are considered to be less significant.

6.2 Modelled Environmental Media

Uncertainties associated with the modelled environmental media are presented in Chapters 10 and 14. Water metal concentrations in the Unuk River were estimated using modelled water quality, which was based on the average source term data and assumed normal (base case) flows. The maxima of the monthly averages were used as an input to the food chain model for operation and closure phases to provide a conservative estimate of water metal concentrations, and therefore a conservative estimate of risks. Risks may be higher during extreme dry year events, but it is assumed that these events will occur infrequently and will therefore have minimal effects on risks. Concentrations of COPCs in soils during operation and closure were assumed to be similar to baseline concentrations because dust modelling predicted no dustfall to the Unuk River habitat. Uncertainties associated with air quality modelling are described in Chapter 7. It was further assumed that metals were 100 % bio-available; therefore, this represents an over-estimation of risks associated with uptake of metals into animals.

6.3 Contaminants of Potential Concern

The COPCs selected for this assessment were metals due to the proposed development of gold deposits. The metals that were selected in the baseline report were also included in this report. Additional metals were selected based on comparing modelled water and baseline sediment concentrations with BC MOE and CCME water and sediment quality guidelines for the protection of aquatic life (BC MOE 2006; CCME 2010b). The guidelines were used as a screening tool and are not applicable for protecting wildlife species.

A conservative approach was taken by applying guidelines for protecting aquatic life because aquatic life is more sensitive than terrestrial life to COPCs in the water. Aquatic life is submerged in water and continuously exposed to COPCs, whereas terrestrial wildlife would be exposed only if they consumed the water. Using regulatory guidelines only selects metals to be assessed and has no influence on the modelled environmental media, food chain model for moose, snowshoe hare, and grouse tissue, or the human exposures to COPCs. Other COPCs (fuel, oil and waste oil, hydraulic fluid, explosives, flocculants, chemical reagents and solvents, lead acid batteries, and oil filters) may be associated with the Project operations. These chemicals will be stored and handled according to safe handling and storage procedures (Chapter 4, Project Description) and are not expected to be released into the environment.

Overall, there is high certainty that all metals that could be a potential concern during mine operations were evaluated.

6.4 Food Chain Model

6.4.1 Vegetation

Metal concentrations were measured in vegetation collected from the Mine Site, Sulphurets Creek, Coulter Creek, and the Unuk River areas during baseline studies and were used as an input to the food chain model for baseline, operation, and closure scenarios. This approach was based on the results of air quality modeling, which showed that dusting is not expected to occur in low-elevation habitats frequented by moose near the Unuk River and other forest habitat species during operation or closure (Figure 7.8-33 in Chapter 7). Therefore, dust will not contribute metals to soils and plant tissues. Uncertainties associated with the air quality model are discussed in Chapter 7.

6.4.2 Wildlife Species

Concentrations in the tissue of moose, snowshoe hare, and grouse were predicted using an uptake model. As with all modelled data, the results are highly dependent on the accuracy of literature-based input parameters (biotransfer factors, ingestion rates), the assumed exposure times, and the quality of the model itself. However, standard guidance and models have been used and clearly described throughout this report.

The main uncertainty in the employed model was the biotransfer factors (BTFs) used. For all animal exposure routes, BTFs from food-to-tissue were used. However, it is unlikely that the BTFs from soil-to-tissue and water-to-tissue are the same as food-to-tissue. In addition, the moose and snowshoe hare BTFs were based on values for beef, as BTFs are not available specifically for moose and snowshoe hare. Similarly, values for the grouse were based on available avian species information (chickens). Notwithstanding, this method is the accepted method to model the uptake of COPCs into animals when empirical data are not available or samples sizes are too small to make conclusions about population tissue concentrations.

The moose, snowshoe hare, and grouse ingestion rates that were used for food, soil, and water were based on guidance on estimating wildlife exposure characteristics provided by the US EPA (1993). The guidance does not account for conditions that are specific to the Mine Site. For example, most soil ingestion by moose occurs incidentally from grazing on grasses or foraging for vegetation on the ground. Moose and other ungulates occasionally consume soils directly to obtain minerals and salts to supplement their nutrient-poor vegetative diet, but this amount is small relative to the amount of soils consumed with vegetation. As a conservative approach, the food chain model assumed that moose would consume soil at the same ingestion rate associated with vegetation consumption. This would overestimate the EDI of all COPCs from the soil ingestion route. The same approach was used for grouse because they may consume small rocky material to aid in physically breaking down food in their gizzards and crops. Overall, it is anticipated that the soil and plant ingestion rates by moose, snowshoe hare, and grouse have been overestimated, which would subsequently result in conservatism in the risk estimates.

The exposure time that moose, grouse, and hare would spend downstream of the Mine Site was conservatively assumed to be 100%. Moose have a large home range (4,220 ha; Demarchi 1996) and it is unlikely that moose will spend all of their time along the Unuk River low-elevation habitat. Therefore, the exposure time factor used in the wildlife model is very conservative for moose. Home ranges for snowshoe hare and grouse are about 40 ha (Ellison 1971) and the entire home range could be within the Unuk River habitat. Therefore, the exposure time was assumed to be one. This assumption results in human health risks being overestimated rather than underestimated.

Other uncertainties associated with the predicted animal tissue concentrations during baseline conditions, operation, and closure include the assumption that the diets of moose, snowshoe hare, and grouse include solely the plants and berries that were collected in the field. Although selected for their prevalence, the plants and berries may not have been representative of the actual foods consumed by the evaluated terrestrial mammals and birds. Therefore, some uncertainty exists in applying the same model to animals with different feeding habits. However, the conservative nature of the food chain model is expected to provide adequate protection against these violations.

6.4.3 Locations of Country Foods Harvested

For all of the country foods evaluated, it was assumed that 100% of the country foods consumed by people each year came from the Unuk River valley near the Mine Site. This is an overestimate, given the vast area available for harvesting, the long distance between the communities and the Mine Site, and its inaccessibility. This overestimation provides conservatism in the risk predictions.

6.4.4 Country Foods Consumption Amounts and Frequency

The consumption amount and frequency data used in this assessment were based on values provided for the Tahltan Nation (Jin 2006). The consumption frequency for all foods was provided for the entire year. Therefore, the weekly consumption frequency was calculated as an average weekly rate and could not be provided for the week where the consumption may be the highest. Therefore, exposure to COPCs during the week of highest consumption may be underestimated in this SLRA.

There is uncertainty in using these data as it is not site specific; it is based on Tahltan Nation consumption from a wide range of areas within the Tahltan Nation asserted territory and not only from areas downstream of the Mine site. In addition, the data do not reflect the consumption of other country foods harvesters who may harvest from areas downstream of the Mine site. For moose, the high frequency and amounts of consumption are considered to be overestimated rather than underestimated.

Consumption amounts and frequencies for toddlers also carry some uncertainty. As a conservative approach, it was assumed that toddlers ranging from six months to four-years old consumed food at a rate of 43% of an adult, based on literature recommendations (Richardson 1997). It is unlikely that toddlers consume roughly half the amount of food that an adult would. This uncertainty is important because the overestimation of food consumption results in the high ER value and current weekly number of servings of moose tissue that toddlers consume. It is probable that the actual exposure to COPCs from the ingestion of country foods is substantially lower for toddlers.

6.5 Toxicity Reference Values

There is uncertainty associated with estimating toxicity benchmarks by extrapolating potential effects on humans from animal studies in the laboratory. Thus, for human health risk assessments, it is a standard practice to assume that people are more sensitive to the toxic effects of a substance than laboratory animals. Therefore, the toxicity benchmarks for human health are set at much lower levels than the animal benchmarks (typically 100 to 1,000 times lower). This large margin ensures that doses less than the toxicity benchmarks are safe and that minor exceedance of these benchmarks are unlikely to cause adverse health effects.

The TRVs are derived for individual contaminants. However, it is recognized that multiple chemicals may be present within a food item and interactions between compounds may result in additivity (overall effect is the sum of the individual effects), antagonism (overall effect is less than the sum of the individual effects), or synergism (overall effect is greater than the sum of the individual effects). Many of these interactions are poorly understood or remain unknown by modern science. Furthermore, numerous physical variables (e.g., media temperature, pH, salinity, hardness, etc.) in natural systems can accelerate or impede these chemical interactions. Because of these environmental variables, as well as poorly understood interactions among different compounds, assessments were only conducted for the individuals COPC levels and not for overall health effects.

6.6 Definition of Health

This country foods assessment uses a science-based approach recommended by Health Canada to protect human receptors from adverse health effects caused by exposure to the selected COPCs (metals). However, it is recognized that health is defined by more than just physical well-being. For instance, social, cultural, nutritional, and economic factors also play a role in a person's overall health status. These health indices have been assessed in other sections of the Application/EIS (Chapters 22 and 23).

7 Conclusions

This country foods SLRA integrated the results of the environmental media baseline studies and modelled predictions, human receptor characteristics and regulatory-based TRVs during baseline conditions, operation, and closure of the KSM Project Mine Site. The potential for residual human health effects caused by the consumption of four country foods (moose, snowshoe hare, grouse, and berries) was assessed through this SLRA. The country foods SLRA methodology was based on Health Canada's guidelines for assessing country foods (Health Canada 2004).

This assessment predicted no unacceptable risks to people from consuming moose, snowshoe hare, grouse, and berries during operation and closure. Based on the measured baseline conditions and the modelled operation and closure conditions, country food quality is not expected to change substantially. This means that country food harvesters can continue to consume moose, snowshoe hare, and grouse and other country foods at the rates and frequencies to which they are accustomed.

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APPENDIX A – PREDICTED TISSUE CONCENTRATIONS

Appendix A. Predicted Tissue Concentrations

Introduction

A food chain model was used to predict metals concentrations in moose, snowshoe hare and grouse meat. Moose, snowshoe hare and grouse may uptake metals from the environment by ingesting vegetation and soil or drinking water. As described in Chapter 25, Human Health, tissue concentrations depend on the metals concentrations in the environmental media and species-specific characteristics (i.e., ingestion rates of each media and the time that an animal spends downsteam of the Mine site).

This section provides details on the methodology of the food chain model and the modelled metals concentrations in the tissue of the terrestrial country foods. The modelled metals concentrations are used in the screening level risk assessment (SLRA).

Moose, snowshoe hare, and grouse tissue concentrations were modelled for three scenarios, baseline, operation, and closure:

1. Baseline scenario: This scenario predicts the metals concentrations in moose, snowshoe hare, and grouse that spend their entire time in the existing environment (pre-Project) downstream of the Mine site.
2. Operation scenario: This scenario predicts the metals concentrations in moose, snowshoe hare, and grouse when the proposed KSM Project (the Project) is operational. The scenario assumes that moose, snowshoe hare, and grouse would spend all of their time in or near the Mine site. Metals concentrations in environmental media (i.e., water) downstream of the Mine Site under the operation scenario were modelled. Modelled water concentrations reflected the water that moose, snowshoe hare, and grouse would drink when frequenting habitat in the Unuk River (UR1 and UR2) low-elevation forests and the lower Sulphurets Creek (SC3). Measured soil and vegetation metals concentrations reflect the soil and vegetation that moose, snowshoe hare, and grouse would eat when they frequent the habitat, because dust is not expected to fall out from the Mine Site in the low-elevation Unuk River habitat (Figure 7.8-33., Chapter 7). Dust from the Colter Creek access road will be very localized and therefore of minor impact. Incidental soil ingestion by wildlife, particularly herbivores, is well documented. These modelled and measured concentrations were used to predict changes in the concentrations of animal tissue during Project operation.
3. Closure scenario: This scenario predicts the metals concentrations in moose, snowshoe hare, and grouse when the proposed Project is being closed. The scenario assumes that moose, snowshoe hare, and grouse would spend all of their time in or near the Mine Site. Metals concentrations in environmental media (i.e., water) were modelled downstream of the Mine Site under the closure scenario. Modelled water concentrations reflected the water that moose, snowshoe hare, and grouse would ingest when they enter the river. Measured soil and vegetation concentrations reflect the surface soil and above-ground vegetation that moose, snowshoe hare, and grouse would eat when they frequent the low-elevation habitat along the Unuk River. Incidental soil ingestion by wildlife, particularly herbivores, is well

documented. These measured concentrations were used to predict changes in the concentrations of animal tissue during Project operation, because dust is not expected to affect these areas (Figure 7.8-33., Chapter 7).

The construction scenario was not modelled because the operation and closure scenarios were expected to have higher potential effects on country foods due to the potential for metals leaching during operation and closure of the Project. The following sections provide the food chain model methods and predicted concentrations for moose, snowshoe hare, and grouse for the scenarios described above.

Methods

The following equation was used to predict terrestrial animal tissue concentrations, C_{meat}:

$$C_{meat}\ (mg/kg) = C_{msoil} + C_{mveg} + C_{mwater}$$

where:
C_{meat} = Concentration of metals in moose, snowshoe hare, or grouse from consuming soil, vegetation, and water.

C_{msoil} = Concentration of metals in meat from the animals' exposure to metals in soil.
C_{mveg} = Concentration of metals in meat from the animals' exposure to metals in vegetation.
C_{mwater} = Concentration of metals in meat from the animals' exposure to metals in water.

The terrestrial wildlife uptake equations used to obtain the concentrations in meat from exposure to soil, vegetation, and water are presented in Table C-1.

Table A-1. Terrestrial Wildlife Uptake Equations

Pathway	Equation and Equation Parameters
Soil ingestion	$C_{spp\text{-}soil} = BTF_{tissue\text{-}food}\ (day/kg) \times C_{soil}\ (mg/kg) \times IR_{soil}\ (mg/day) \times ET$
Vegetation ingestion	$C_{spp\text{-}veg} = BTF_{tissue\text{-}food}\ (day/kg) \times C_{veg}\ (mg/kg\ wet\ weight) \times IR_{veg}\ (mg\ wt/day) \times ET$
Water ingestion	$C_{spp\text{-}water} = BTF_{tissue\text{-}food}\ (day/kg) \times C_{water}\ (mg/L) \times IR_{water}\ (L/day) \times ET$

BTF = biotransfer Factor (day/kg)for moose, snowshoe hare, and grouse
IR = daily ingestion rate of media
C = concentration of metals in media in baseline near the Mine site
ET = exposure time spent downstream of Mine site (this includes fraction of daily consumption).

The calculations presented above are based on the document entitled *Guidance for Country Foods Surveys for the Purpose of Human Health Risk Assessment*, prepared for Health Canada by Golder and Associates (2005). The next three sections of this document present the following model input parameters:

1. Biotransfer factors (BTF) for the wildlife species and metals.
2. Metals concentration in media under baseline, operations, and closure conditions.
3. Wildlife exposure characteristics: ingestion rate (IR) and exposure time (ET).

Biotransfer Factors

When any chemical substance is taken up, a fraction of the total amount is absorbed into the body and the remainder is excreted. The BTF is a conversion factor, which represents the absorbed fraction of metals from the diet. BTF values are metal-specific and species-specific, and are typically provided for agriculturally important food species. No data on moose or snowshoe hare BTFs were available; therefore, BTF values for cows (BTF_{beef}) were used as the closest related herbivorous mammal (US EPA 2005; RAIS 2010). For grouse, $BTF_{chicken}$ values were used to represent the closest related avian species (Staven et al. 2003; US EPA 2005). When BTF values were not available for a specific metal, the BTF for a metal with similar physiochemical properties was substituted. Metals were considered similar in their physiochemical characteristics if they were immediately above or below each other on the periodic table of elements. For example, the $BTF_{chicken}$ for aluminum was not available. The BTF value for gallium was substituted because gallium is below aluminum on the periodic table.

Table A-2 presents the BTF for all metals that were assessed.

Table A-2. Biotransfer Factors

	BTF beef		BTF chicken	
COPC	**day/kg**	**Reference**	**day/kg**	**Reference**
Aluminum (Al)-Total	0.0015	1	0.8	3
Arsenic (As)-Total	0.002		0.83	2
Barium (Ba)-Total	0.00015		0.009	2
Beryllium (Be)-Total	0.001		0.4	2
Cadmium (Cd)-Total	0.00012		0.10625	
Chromium (Cr)-Total	0.0055		0.2	2
Cobalt (Co)-Total	0.01	2	2	2
Copper (Cu)-Total	0.009	1	0.5	2
Lead (Pb)-Total	0.0003	4	0.8	2,5
Mercury (Hg)-Total	0.01	1	0.03	2
Molybdenum (Mo)-Total	0.001	2	0.18	2
Nickel (Ni)-Total	0.006		0.001	2
Selenium (Se)-Total	0.002265		1.12625	
Silver (Ag)-Total	0.003		2	2
Tin (Sn)-Total	0.08	2	0.8	2
Vanadium (V)-Total	0.0025	1	0.0003	
Zinc (Zn)-Total	0.00009		0.00875	

References:
1 RAIS 2010
2 Staven 2003
3 BTF chicken for aluminum is based on BTF chicken for gallium
4 US EPA 2005
5 based on As

Metals Concentrations in Environmental Media

Metals concentrations in environmental media were assessed for three scenarios: baseline, operation, and closure. Metals concentrations in the vegetation, soil, and water were measured during baseline studies from 2007 to 2012 to establish the existing environmental conditions (Rescan 2010b, 2010a, 2012). Metals concentrations in the water downstream of the Mine Site (stations SC3, UR1, and UR2) during Project operation and closure were modelled (Appendix 14-J) and the maxima of the monthly base flow predictions were averaged for input into the wildlife food chain model. The maxima of measured baseline stations upstream and downstream of the proposed Mine Site (SC3, UR0, UR1A, UR1, UR2, SUNR, CC1, ECM7, and ECM8) are used in the wildlife food chain model for the baseline scenario. This represents a conservative estimate of the concentrations that wildlife will encounter in the low-elevation habitat of this drainage. A summary of the data for the scenarios is presented in Table A-3. Baseline concentrations are presented as the 95% upper confidence limit of the mean. The 95% upper confidence limit of the mean encompasses the range of variability of measured concentrations relative to the mean concentration and was calculated in Excel an equation from *Calculating Upper Confidence Limits for Exposure Point Calculations at Hazardous Waste Sites* (US EPA 2002). The Mine Site conditions (metals concentrations in water) were modelled as the maximum of the monthly averaged concentrations for operation and closure using base flow and the 95th percentile of the source data as the most conservative estimate. All of the vegetation and surface soil that animals consume will be outside of the dust deposition zone from the Mine Site (Figure 7.8-33 in Chapter 7) and represented during baseline, operation, and closure using the baseline vegetation and soil metals concentrations. The metals concentrations ($C_{spp\text{-}media}$) were used to predict the concentrations in moose, snowshoe hare, and grouse.

The rationale for the metals selected was presented in the main text of the country foods SLRA.

Table A-3. Metals Concentrations in Surface Water, Soil, and Plant Tissue

COPC (Total)	Measured Baseline (95% UCLM)			Mine Area Operations and Closure			
	Vegetation mg/kg ww $C_{base\text{-}veg}$	Soil mg/kg dw $C_{base\text{-}soil}$	Water mg/L $C_{base\text{-}water}$	95% UCLM Vegetation mg/kg ww $C_{MA\text{-}veg}$	95% UCLM Soil mg/kg dw $C_{MA\text{-}soil}$	Water-Operations mg/L $C_{MA\text{-}water}$	Water-Closure mg/L $C_{MA\text{-}water}$
Aluminum	19.7	30081.5	2.39	19.7	30082	8.5	9.1
Arsenic	0.0110	65.9	0.00412	0.011	65.9	0.0092	0.0098
Barium	13.7	400.9	0.0683	13.7	400.9	0.1680	0.1800
Beryllium	0.040	2.0	0.000240	0.0397	2.0	0.00070	0.00068
Cadmium	0.234	0.792	0.0000294	0.2340	0.8	0.00073	0.00076
Chromium	0.107	111.3	0.00359	0.107	111.3	0.0125	0.0133
Cobalt	0.126	42.0	0.00204	0.126	42.0	0.00569	0.00613
Copper	1.278	360.1	0.0483	1.3	360.1	0.0791	0.0837
Lead	0.0147	35.0	0.00287	0.0147	35.05	0.00658	0.00707

(continued)

Table A-3. Metals Concentrations in Surface Water, Soil, and Plant Tissue (completed)

COPC (Total)	Measured Baseline (95% UCLM)			Mine Area Operations and Closure			
	Vegetation mg/kg ww $C_{base-veg}$	Soil mg/kg dw $C_{base-soil}$	Water mg/L $C_{base-water}$	95% UCLM Vegetation mg/kg ww C_{MA-veg}	95% UCLM Soil mg/kg dw $C_{MA-soil}$	Water-Operations mg/L $C_{MA-water}$	Water-Closure mg/L $C_{MA-water}$
Mercury	0.0041	0.758	0.0000105	0.0041	0.8	0.0000405	0.0000420
Molybdenum	0.157	43.4	0.00285	0.157	43.4	0.0035	0.0031
Nickel	0.377	58.3	0.00349	0.4	58.3	0.0109	0.0117
Selenium	0.110	4.0	0.000898	0.110	4.0	0.0041	0.0040
Silver	nd	2.5	0.000341	nd	2.5	0.00019	0.00021
Tin	0.025	8.4	0.000937	0.0250	8.4	-	-
Vanadium	0.059	176.4	0.0093	0.1	176.4	0.0361	0.0388
Zinc	12.8	128.2	0.0426	12.8	128.2	0.0625	0.0665

Wildlife Exposure Characteristics

Terrestrial wildlife characteristics are species-specific parameters that define the characteristics of the species. These parameters were used to estimate the amount of time an animal would spend in the area and the amount of environmental media that each species would be exposed to during that time. Table A-4 presents the terrestrial wildlife characteristics that were used to predict metals concentrations in moose, snowshoe hare, and grouse. The parameters included the ingestion rate (IR) of each media (IR_{veg}, IR_{soil}, and IR_{water}) and the ET, or fraction of the year spent in the area downstream of the Mine site. The IR values were based on guidance from the Oakridge National Library (ORNL 1997).

The ET value for moose, snowshoe hare, and grouse under the baseline, operation, and closure scenarios is 1.0, as these animals could spend 100% of their time downstream of the Mine Site.

For moose, a non-migratory home range of 4,220 ha was assumed (Demarchi 2003)and the Unuk River low-elevation forests represents suitable habitat (Chapter 18). In addition, moose were assumed to be active in their home range for the entire year because during winter months they may attempt to forage for grass and lichens beneath the snow and they have been observed in summer and winter (Figure 18.1-1 in Chapter 18). Therefore, the ET was assumed to be 1.0.

For grouse, the home range (40 ha) is less than the Unuk River area (Ellison 1971). The home range for snowshoe hare (4 ha) is also less than the Unuk River area (US EPA 1993). Thus, the entire home range of these animals is within the assessed area and the ET would be 1.0. This conservative assumption would result in human health risks being overestimated rather than underestimated. Uncertainties associated with this assumption are presented in the main text of the country foods SLRA.

Table A-4. Terrestrial Wildlife Characteristics

Parameter	Unit	Symbol	Moose	Grouse	Hare
Bodyweight	kg	BW	461	1.2	1.35
Total Food Ingestion Rate	kg/day	IR	9.95	0.085	0.109
Vegetation Ingestion Rate	kg-ww/day	IR_{veg}	9.8	0.084	0.105
Soil Ingestion Rate	kg-dw/day	IR_{soil}	0.15	0.07	0.0036
Water Ingestion Rate	L/day	IR_{water}	25	0.07	0.0135
Baseline Scenario					
Exposure Time		ET_{base}	1	1	1
Operations Scenario					
Exposure Time		ET_{op}	1	1	1
Closure Scenario					
Exposure Time		ET_{clo}	1	1	1

FOOD CHAIN MODEL Sample Calculation

To calculate the amount of metals that each ingestion pathway contributes, a generic equation for all ingestion routes is presented in Table A-5, followed by media-specific equations.

Table A-5. Terrestrial Wildlife Uptake Equations

Pathway	Equation and Parameters
Generic Equation	$C_{spp\text{-}media} = BTF \times C \times IR \times ET$
Baseline Ingestion Equations	
Soil Ingestion	$C_{spp\text{-}soil} = BTF_{spp\text{-}metal} \times C_{base\text{-}soil} \times IR_{soil} \times ET_{base}$
Vegetation Ingestion	$C_{spp\text{-}veg} = BTF_{spp\text{-}metal} \times C_{base\text{-}veg} \times IR_{veg} \times ET_{base}$
Water Ingestion	$C_{spp\text{-}water} = BTF_{spp\text{-}metal} \times C_{base\text{-}water} \times IR_{water} \times ET_{base}$
Operations Ingestion Equations	
Soil Ingestion	$C_{spp\text{-}soil} = BTF_{spp\text{-}metal} \times C_{base\text{-}soil} \times IR_{soil} \times ET_{op}$
Vegetation Ingestion	$C_{spp\text{-}veg} = BTF_{spp\text{-}metal} \times C_{base\text{-}veg} \times IR_{veg} \times ET_{op}$
Water Ingestion	$C_{spp\text{-}water} = BTF_{spp\text{-}metal} \times C_{op\text{-}water} \times IR_{water} \times ET_{op}$
Closure Ingestion Equations	
Soil Ingestion	$C_{spp\text{-}soil} = BTF_{spp\text{-}metal} \times C_{base\text{-}soil} \times IR_{soil} \times ET_{clo}$
Vegetation Ingestion	$C_{spp\text{-}veg} = BTF_{spp\text{-}metal} \times C_{base\text{-}veg} \times IR_{veg} \times ET_{clo}$
Water Ingestion	$C_{spp\text{-}water} = BTF_{spp\text{-}metal} \times C_{clo\text{-}water} \times IR_{water} \times ET_{clo}$

$C_{spp\text{-}media}$ = Contribution of metals in animal tissue from media ingestion (mg/kg)
BTF = Biotransfer factor for the animal species and metal (day/kg)
C = Media concentration of metals in either TMF or baseline conditions (mg/kg)
IR = Daily ingestion rate of media (kg/day)
ET = Exposure time spent in the TMF or baseline area

A sample calculation is presented in Table A-6 for aluminum concentrations in moose tissue resulting from ingesting soil, water, and vegetation under the baseline scenario.

Table A-6. Sample Calculation of Maximum Aluminum Concentration in Moose Muscle Tissue from Exposure to Surface Waters, Soil, and Vegetation under Baseline Conditions

Overall Equation:	
$C_{meat} = C_{ssp\text{-}veg} + C_{ssp\text{-}soil} + C_{ssp\text{-}water}$	
Where:	
$C_{spp\text{-}veg} = BTF_{spp\text{-}metal} \times C_{base\text{-}veg} \times IR_{veg} \times ET_{base}$	
$C_{spp\text{-}soil} = BTF_{spp\text{-}metal} \times C_{base\text{-}soil} \times IR_{soil} \times ET_{base}$	
$C_{spp\text{-}water} = BTF_{spp\text{-}metal} \times C_{base\text{-}water} \times IR_{water} \times ET_{base}$	
Parameters:	
C_{meat}	= Total concentration of metal (aluminum) in animal tissue (moose) from all ingestion pathways
$C_{spp\text{-}veg}$	= Total concentration of metal (aluminum) in animal tissue (moose) from vegetation ingestion
$C_{spp\text{-}soil}$	= Total concentration of metal (aluminum) in animal tissue (moose) from soil ingestion
$C_{spp\text{-}water}$	= Total concentration of metal (aluminum) in animal tissue (moose) from water ingestion
$BTF_{beef\text{-}aluminum}$	= Biotransfer factor from food consumption to tissues for a selected metal
C	= Media concentration of metal at baseline
$IR_{soil/veg/water}$	= Ingestion rate of media (i.e., soil, vegetation, or water)
ET_{base}	= Exposure time in the Project area at baseline
Sample Calculation:	
$C_{spp\text{-}veg}$	= (0.0015 day/kg) x (19.7 mg/kg ww) x (9.8 kg/day) x 1
	= 0.289 mg/kg
$C_{spp\text{-}soil}$	= (0.0015 day/kg) x (39,000 mg/kg dw) x (0.15 kg/day) x 1
	= 6.77 mg/kg
$C_{spp\text{-}water}$	= (0.0015mg/kg) x (2.39 mg/L) x 25 L/day) x 1
	= 0.0898 mg/kg
C_{meat}	= (0.340+6.77+0.0118) mg/kg
	= 7.15 mg/kg

FOOD CHAIN MODEL RESULTS

Tables A-7, A-8 and A-9 present the modelled moose, snowshoe hare, and grouse concentrations for the baseline, operation, and closure scenarios, respectively. Each ingestion pathway (i.e., soil, water, and vegetation) contributes to the total concentration of metals in moose, snowshoe hare, and grouse ($C_{base\text{-}moose}$, $C_{base\text{-}grouse}$, $C_{base\text{-}hare}$, $C_{OP\text{-}moose}$, etc.). These metals concentrations in moose, snowshoe hare, and grouse tissue were used in the country foods SLRA to calculate the estimated daily intake of metals that people who eat moose, snowshoe hare, and grouse downstream of the Mine Site would be exposed to.

Table A-7. Metal Concentrations in Moose, Grouse, and Hare Tissue: Baseline Scenario (mg/kg)

COPC (Total)	$C_{moose\text{-}veg}$	$C_{moose\text{-}soil}$	$C_{moose\text{-}water}$	$C_{base\text{-}moose}$	$C_{grouse\text{-}veg}$	$C_{grouse\text{-}soil}$	$C_{grouse\text{-}water}$	$C_{base\text{-}grouse}$	$C_{hare\text{-}veg}$	$C_{hare\text{-}soil}$	$C_{hare\text{-}water}$	$C_{base\text{-}hare}$
Aluminum	2.90E-01	6.77E+00	8.98E-02	**7.15E+00**	1.32E+00	1.68E+03	1.34E-01	**1.69E+03**	3.11E-03	1.62E-01	4.83E-05	**1.65E-01**
Arsenic	2.16E-04	1.98E-02	2.06E-04	**2.02E-02**	7.70E-04	3.83E+00	2.39E-04	**3.83E+00**	2.33E-06	4.72E-04	1.11E-07	**4.74E-04**
Barium	2.01E-02	9.02E-03	2.56E-04	**2.94E-02**	1.04E-02	2.53E-01	4.30E-05	**2.63E-01**	2.16E-04	2.15E-04	1.38E-07	**4.32E-04**
Beryllium	3.89E-04	2.94E-04	6.00E-06	**6.89E-04**	1.33E-03	5.49E-02	6.71E-06	**5.63E-02**	4.18E-06	7.02E-06	3.23E-09	**1.12E-05**
Cadmium	2.75E-04	1.43E-05	8.83E-08	**2.89E-04**	2.09E-03	5.89E-03	2.19E-07	**7.98E-03**	2.96E-06	3.40E-07	4.75E-11	**3.30E-06**
Chromium	5.76E-03	9.18E-02	4.94E-04	**9.81E-02**	1.80E-03	1.56E+00	5.03E-05	**1.56E+00**	6.19E-05	2.19E-03	2.66E-07	**2.25E-03**
Cobalt	1.24E-02	6.30E-02	5.11E-04	**7.59E-02**	2.12E-02	5.88E+00	2.86E-04	**5.90E+00**	1.33E-04	1.50E-03	2.75E-07	**1.64E-03**
Copper	1.13E-01	4.86E-01	1.09E-02	**6.10E-01**	5.37E-02	1.26E+01	1.69E-03	**1.27E+01**	1.21E-03	1.16E-02	5.84E-06	**1.28E-02**
Lead	4.31E-05	1.58E-03	2.15E-05	**1.64E-03**	9.85E-04	1.96E+00	1.61E-04	**1.96E+00**	4.63E-07	3.76E-05	1.16E-08	**3.81E-05**
Mercury	4.06E-04	1.14E-03	2.63E-06	**1.55E-03**	1.04E-05	1.59E-03	2.21E-08	**1.60E-03**	4.37E-06	2.71E-05	1.42E-09	**3.15E-05**
Molybdenum	1.54E-03	6.51E-03	7.12E-05	**8.12E-03**	2.37E-03	5.47E-01	3.59E-05	**5.49E-01**	1.65E-05	1.55E-04	3.83E-08	**1.72E-04**
Nickel	2.22E-02	5.24E-02	5.23E-04	**7.51E-02**	3.17E-05	4.08E-03	2.44E-07	**4.11E-03**	2.38E-04	1.25E-03	2.81E-07	**1.49E-03**
Selenium	2.43E-03	1.36E-03	5.08E-05	**3.85E-03**	1.04E-02	3.16E-01	7.08E-05	**3.27E-01**	2.61E-05	3.25E-05	2.74E-08	**5.87E-05**
Silver	nc	1.12E-03	0.00E+00	**1.12E-03**	nc	3.47E-01	0.00E+00	**3.47E-01**	nc	2.66E-05	0.00E+00	**2.66E-05**
Tin	1.96E-02	1.01E-01	1.87E-03	**1.22E-01**	1.68E-03	4.70E-01	5.24E-05	**4.72E-01**	2.10E-04	2.40E-03	1.01E-06	**2.61E-03**
Vanadium	1.45E-03	6.61E-02	8.64E-03	**7.62E-02**	1.49E-06	3.70E-03	2.90E-06	**3.71E-03**	1.55E-05	1.58E-03	4.65E-06	**1.60E-03**
Zinc	1.13E-02	1.73E-03	7.68E-07	**1.30E-02**	9.40E-03	7.85E-02	2.09E-07	**8.79E-02**	1.21E-04	4.13E-05	4.13E-10	**1.62E-04**

nc not calculated due to lack of environmental media data.

Table A-8. Metal Concentrations in Moose, Grouse, and Hare Tissue: Operations Scenario (mg/kg)

COPC (Total)	$C_{moose-veg}$	$C_{moose-soil}$	$C_{moose-water}$	$C_{Op-moose}$	$C_{grouse-veg}$	$C_{grouse-soil}$	$C_{grouse-water}$	$C_{Op-grouse}$	$C_{hare-veg}$	$C_{hare-soil}$	$C_{hare-water}$	$C_{Op-hare}$
Aluminum	2.90E-01	6.77E+00	2.76E-01	**7.33E+00**	1.32E+00	1.68E+03	4.12E-01	**1.69E+03**	3.11E-03	1.62E-01	1.48E-04	**1.65E-01**
Arsenic	2.16E-04	1.98E-02	6.00E-04	**2.06E-02**	7.70E-04	3.83E+00	6.97E-04	**3.83E+00**	2.33E-06	4.72E-04	3.23E-07	**4.74E-04**
Barium	2.01E-02	9.02E-03	5.89E-04	**2.97E-02**	1.04E-02	2.53E-01	9.89E-05	**2.63E-01**	2.16E-04	2.15E-04	3.17E-07	**4.32E-04**
Beryllium	3.89E-04	2.94E-04	2.18E-05	**7.05E-04**	1.33E-03	5.49E-02	2.44E-05	**5.63E-02**	4.18E-06	7.02E-06	1.17E-08	**1.12E-05**
Cadmium	2.75E-04	1.43E-05	3.42E-06	**2.93E-04**	2.09E-03	5.89E-03	8.48E-06	**7.99E-03**	2.96E-06	3.40E-07	1.84E-09	**3.30E-06**
Chromium	5.76E-03	9.18E-02	1.44E-03	**9.90E-02**	1.80E-03	1.56E+00	1.47E-04	**1.56E+00**	6.19E-05	2.19E-03	7.77E-07	**2.25E-03**
Cobalt	1.24E-02	6.30E-02	1.32E-03	**7.67E-02**	2.12E-02	5.88E+00	7.36E-04	**5.90E+00**	1.33E-04	1.50E-03	7.08E-07	**1.64E-03**
Copper	1.13E-01	4.86E-01	2.61E-02	**6.25E-01**	5.37E-02	1.26E+01	4.06E-03	**1.27E+01**	1.21E-03	1.16E-02	1.40E-05	**1.28E-02**
Lead	4.31E-05	1.58E-03	4.68E-05	**1.67E-03**	9.85E-04	1.96E+00	3.49E-04	**1.96E+00**	4.63E-07	3.76E-05	2.52E-08	**3.81E-05**
Mercury	4.06E-04	1.14E-03	8.25E-06	**1.55E-03**	1.04E-05	1.59E-03	6.93E-08	**1.60E-03**	4.37E-06	2.71E-05	4.44E-09	**3.15E-05**
Molybdenum	1.54E-03	6.51E-03	1.02E-04	**8.15E-03**	2.37E-03	5.47E-01	5.12E-05	**5.49E-01**	1.65E-05	1.55E-04	5.46E-08	**1.72E-04**
Nickel	2.22E-02	5.24E-02	1.41E-03	**7.60E-02**	3.17E-05	4.08E-03	6.57E-07	**4.11E-03**	2.38E-04	1.25E-03	7.57E-07	**1.49E-03**
Selenium	2.43E-03	1.36E-03	2.90E-04	**4.09E-03**	1.04E-02	3.16E-01	4.04E-04	**3.27E-01**	2.61E-05	3.25E-05	1.56E-07	**5.88E-05**
Silver	nc	1.12E-03	1.29E-05	**1.13E-03**	nc	3.47E-01	2.41E-05	**3.47E-01**	nc	2.66E-05	6.94E-09	**2.67E-05**
Tin	1.96E-02	1.01E-01	1.87E-03	**1.22E-01**	1.68E-03	4.70E-01	5.24E-05	**4.72E-01**	2.10E-04	2.40E-03	1.01E-06	**2.61E-03**
Vanadium	1.45E-03	6.61E-02	1.93E-03	**6.95E-02**	1.49E-06	3.70E-03	6.49E-07	**3.71E-03**	1.55E-05	1.58E-03	1.04E-06	**1.60E-03**
Zinc	1.13E-02	1.73E-03	2.06E-04	**1.32E-02**	9.40E-03	7.85E-02	5.60E-05	**8.80E-02**	1.21E-04	4.13E-05	1.11E-07	**1.63E-04**

nc not calculated due to lack of environmental media data.

Table A-9. Metal Concentrations in Moose, Grouse, and Hare Tissue: Closure Scenario (mg/kg)

COPC (Total)	$C_{moose\text{-}veg}$	$C_{moose\text{-}soil}$	$C_{moose\text{-}water}$	$C_{Clo\text{-}moose}$	$C_{grouse\text{-}veg}$	$C_{grouse\text{-}soil}$	$C_{grouse\text{-}water}$	$C_{Clo\text{-}grouse}$	$C_{hare\text{-}veg}$	$C_{hare\text{-}soil}$	$C_{hare\text{-}water}$	$C_{Clo\text{-}hare}$
Aluminum	2.90E-01	6.77E+00	2.99E-01	**7.36E+00**	1.32E+00	1.68E+03	4.47E-01	**1.69E+03**	3.11E-03	1.62E-01	1.61E-04	**1.65E-01**
Arsenic	2.16E-04	1.98E-02	6.45E-04	**2.06E-02**	7.70E-04	3.83E+00	7.49E-04	**3.83E+00**	2.33E-06	4.72E-04	3.47E-07	**4.74E-04**
Barium	2.01E-02	9.02E-03	6.30E-04	**2.98E-02**	1.04E-02	2.53E-01	1.06E-04	**2.63E-01**	2.16E-04	2.15E-04	3.39E-07	**4.32E-04**
Beryllium	3.89E-04	2.94E-04	2.12E-05	**7.04E-04**	1.33E-03	5.49E-02	2.37E-05	**5.63E-02**	4.18E-06	7.02E-06	1.14E-08	**1.12E-05**
Cadmium	2.75E-04	1.43E-05	3.66E-06	**2.93E-04**	2.09E-03	5.89E-03	9.07E-06	**7.99E-03**	2.96E-06	3.40E-07	1.97E-09	**3.30E-06**
Chromium	5.76E-03	9.18E-02	1.54E-03	**9.91E-02**	1.80E-03	1.56E+00	1.57E-04	**1.56E+00**	6.19E-05	2.19E-03	8.29E-07	**2.25E-03**
Cobalt	1.24E-02	6.30E-02	1.42E-03	**7.68E-02**	2.12E-02	5.88E+00	7.95E-04	**5.90E+00**	1.33E-04	1.50E-03	7.64E-07	**1.64E-03**
Copper	1.13E-01	4.86E-01	2.84E-02	**6.27E-01**	5.37E-02	1.26E+01	4.41E-03	**1.27E+01**	1.21E-03	1.16E-02	1.53E-05	**1.28E-02**
Lead	4.31E-05	1.58E-03	5.06E-05	**1.67E-03**	9.85E-04	1.96E+00	3.77E-04	**1.96E+00**	4.63E-07	3.76E-05	2.72E-08	**3.81E-05**
Mercury	4.06E-04	1.14E-03	8.58E-06	**1.55E-03**	1.04E-05	1.59E-03	7.20E-08	**1.60E-03**	4.37E-06	2.71E-05	4.61E-09	**3.15E-05**
Molybdenum	1.54E-03	6.51E-03	8.40E-05	**8.13E-03**	2.37E-03	5.47E-01	4.23E-05	**5.49E-01**	1.65E-05	1.55E-04	4.52E-08	**1.72E-04**
Nickel	2.22E-02	5.24E-02	1.52E-03	**7.61E-02**	3.17E-05	4.08E-03	7.07E-07	**4.11E-03**	2.38E-04	1.25E-03	8.15E-07	**1.49E-03**
Selenium	2.43E-03	1.36E-03	2.78E-04	**4.07E-03**	1.04E-02	3.16E-01	3.87E-04	**3.27E-01**	2.61E-05	3.25E-05	1.50E-07	**5.88E-05**
Silver	nc	1.12E-03	1.40E-05	**1.13E-03**	nc	3.47E-01	2.60E-05	**3.47E-01**	nc	2.66E-05	7.51E-09	**2.67E-05**
Tin	1.96E-02	1.01E-01	1.87E-03	**1.22E-01**	1.68E-03	4.70E-01	5.24E-05	**4.72E-01**	2.10E-04	2.40E-03	1.01E-06	**2.61E-03**
Vanadium	1.45E-03	6.61E-02	2.08E-03	**6.97E-02**	1.49E-06	3.70E-03	6.99E-07	**3.71E-03**	1.55E-05	1.58E-03	1.12E-06	**1.60E-03**
Zinc	1.13E-02	1.73E-03	2.22E-04	**1.32E-02**	9.40E-03	7.85E-02	6.04E-05	**8.80E-02**	1.21E-04	4.13E-05	1.19E-07	**1.63E-04**

nc not calculated due to lack of environmental media data.

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APPENDIX B – SAMPLE CALCULATION OF THE ESTIMATED DAILY INTAKE OF ALUMINUM FOR TODDLERS CONSUMING MOOSE TISSUE DURING BASELINE

Appendix B. Sample Calculation of the Estimated Daily Intake of Aluminum for Toddlers Consuming Moose Tissue during Baseline

$$EDI_{meat} = \frac{IR \times F_s \times C_{meat}}{BW}$$

$$EDI_{meat} = \frac{0.0916 \text{ kg/day} \times 0.997 \times 7.15 \text{ mg/kg}}{16.5 \text{ kg}}$$

$$EDI_{meat} = 0.0396 \text{ mg/kg bw/day}$$

Parameter

IR =	Ingestion rate (kg/day)
F_s =	Fraction of year consuming meat
C_{meat} =	Predicted aluminum concentration in meat (95% UCLM, mg/kg)
BW =	Body weight of receptor (kg)
EDI =	Estimated daily intake (mg/kg bw/day)

Parameter Value

IR =	0.0916
F_s =	0.997
C_{meat} =	7.15
BW =	16.5
EDI =	0.0396

APPENDIX C – SAMPLE CALCULATION OF ESTIMATED DAILY LIFETIME EXPOSURE OF ARSENIC FOR AN ADULT CONSUMING MOOSE TISSUE (BASELINE)

Appendix C. Sample Calculation of Estimated Daily Lifetime Exposure of Arsenic for an Adult Consuming Moose Tissue (Baseline)

$$ELDE_{country\ food} = \frac{IR \times Fs \times C_{countryfood} \times YE}{BW \times LE}$$

$ELDE_{country\ food}$ = estimated lifetime daily intake of coutry food (mg/kg bw/day)
IR = ingestion rate (kg/day)
$C_{countryfood}$ = metal concentration in country food (mg/kg)
Fs = fraction of year consuming country food (unitless)
YE = years exposed (yr)
BW = receptor body weight (kg)
LE = life expectancy (yr)

Parameter	**Value**
IR	0.213 kg/day
$C_{countryfood}$	0.020 mg/kg ww
Fs	1
YE = LE	70
BW	70.7 kg

$$ELDE_{country\ food} = \frac{0.213 \text{ kg/day} \times 1 \times 0.02 \text{ mg/kg ww} \times 70 \text{ yr}}{70.7 \text{ kg bw} \times 70 \text{ yr}}$$

$ELDE_{country\ food}$ = 6.07×10^{-5} mg/kg bw/day

APPENDIX D – RECOMMENDED MAXIMUM WEEKLY INTAKE: SAMPLE CALCULATIONS AND RESULTS

Appendix D. Recommended Maximum Weekly Intake: Sample Calculations and Results

The recommended maximum weekly intake (RMWI) is the maximum amount of country foods that can be consumed by people weekly without exceeding an exposure ratio of 0.2 for any of the metals.

The RMWI was calculated based on *The Canadian Handbook on Health Impact Assessment* (Health Canada 2004) using the following equation:

$$RMWI = \frac{TRV \text{ x } BW \text{ x } 7}{C_{food}}$$

where:

RMWI = recommended maximum weekly intake of food (g/week)
TRV = toxicological reference value (µg/kg BW/day)
BW = receptor body weight (kg)
7 = days/week
C_{food} = metal concentration in food (µg/g)

RMWIs for each metal were calculated for toddlers and adults under the baseline, operation, and closure scenarios. The following presents a sample calculation for the RMWI for a toddler who is exposed to aluminum from consuming moose tissue under the baseline scenario.

$$RMWI = \frac{1.0 \text{ mg/kg/d x } 16.5\text{kg x } 7\text{d/week}}{7.15 \text{ mg/kg}}$$

$$= 16.2 \text{ kg moose /week}$$

The metal with the lowest RMWI was selected as the final RMWI. The metal with the lowest RMWI is considered the final RMWI because it would be the first metal where consuming country foods would result in an ER of 0.2. Table D-1 presents a sample calculation of the RMWI for toddlers consuming moose tissue under the baseline scenario. The lowest RMWI is 1.2 kg moose/week for toddlers based on modelled chromium concentrations in moose.

Tables D-2 and D-3 present the RMWIs and final RMWIs for each receptor, country food, and scenario. Under the baseline, operation, and closure scenarios, the final RMWIs for moose, and snowshoe hare, and berries were based on predicted chromium concentrations. For grouse, final RMWIs were based on predicted arsenic concentration.

Table D-1. Sample Calculation of RMWI in Toddlers Consuming Moose Tissue under Baseline Scenario

$$RMWI_{metal} = \frac{TRV_{metal} \times BW_{toddler} \times 7}{C_{base\text{-}moose}}$$

COPC	TRV_{metal} mg/kg/d	$BW_{toddler}$ kg	$C_{base\text{-}moose}$ mg/kg	$RMWI_{metal}$ kg/week
Aluminum	1	16.5	7.2	16.0
Arsenic	0.0003	16.5	0.020	1.7
Barium	0.2	16.5	0.022	1,056.2
Beryllium	0.002	16.5	0.000627	368.4
Cadmium	0.001	16.5	0.000073	1,583.9
Chromium	0.001	16.5	0.100	1.2
Cobalt	0.001	16.5	0.075	1.5
Copper	0.091	16.5	0.575	18.3
Mercury	0.0003	16.5	0.0013	26.0
Molybdenum	23	16.5	0.0071	376,490.2
Nickel	0.011	16.5	0.087	14.7
Selenium	0.0062	16.5	0.0035	205.8
Silver	0.005	16.5	0.0011	516.9
Vanadium	0.009	16.5	0.0676	15.4
Zinc	0.48	16.5	0.0086	6,484.2
Fluoride	0.105	16.5	0.129	93.7

Highlighted = lowest (final) RMWI = 1.2 kg/week

Table D-2. Summary of Recommended Maximum Weekly Intakes (kg/week) for Adults

COPC	Baseline RMWI				Operations RMWI				Closure RMWI			
	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries
Aluminum	69	0.29	3005	124	67	0.29	3003	124	67	0.29	3003	124
Arsenic	7	0.04	313	34	7	0.04	313	34	7	0.04	313	34
Barium	3365	376	229253	43	3328	376	229158	43	3323	376	229146	43
Beryllium	1437	18	88379	38	1405	18	88312	38	1406	18	88314	38
Cadmium	1710	62	150130	191	1690	62	150048	191	1689	62	150043	191
Chromium	5	0.3	220	11.5	5	0.3	220	11	5	0.3	220	11
Cobalt	7	0.08	302	57	6	0.08	302	57	6	0.08	302	57
Copper	114	6	5444	61	112	6	5440	61	111	6	5440	61
Lead	1085	1	46740	207	249	0	10904	48	249	0	10904	48
Mercury	96	93	4713	705	96	93	4713	705	96	93	4713	705
Molybdenum	1706797	25232	80600821	58589	1700449	25231	80593175	58589	1704108	25231	80597590	58589
Nickel	72	1325	3653	79	72	1324	3652	79	72	1324	3652	79
Selenium	733	9	48052	33	690	9	47947	33	692	9	47952	33
Silver	2216	7	92854	nd	2191	7	92830	nd	2189	7	92828	nd
Tin	2431	630	113576	6046	2431	630	113576	6046	2431	630	113576	6046
Vanadium	58	1201	2786	103	64	1202	2792	103	64	1202	2792	103
Zinc	21683	3208	1736106	159	21347	3206	1734928	159	21321	3206	1734835	159
Lowest RMWI	**5.0**	**0.04**	**220**	**11.5**	**5.0**	**0.04**	**220**	**11.5**	**5.0**	**0.04**	**220**	**11.5**

highlighted *COPC that determines the lowest (final) RMWI*

Table D-3. Summary of Recommended Maximum Weekly Intakes (kg/week) for Toddlers

COPC	Baseline RMWI				Operations RMWI				Closure RMWI			
	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries	Moose	Grouse	Hare	Berries
Aluminum	16	0.07	701	29	16	0.07	701	29	16	0.07	701	29
Arsenic	2	0.01	73	8	2	0.01	73	8	2	0.01	73	8
Barium	785	88	53503	10	777	88	53481	10	776	88	53478	10
Beryllium	335	4	20626	9	328	4	20610	9	328	4	20611	9
Cadmium	399	14	35037	45	394	14	35018	45	394	14	35017	45
Chromium	1	0.1	51	3	1	0.1	51	3	1	0.1	51	3
Cobalt	2	0.02	71	13	2	0.02	71	13	2	0.02	71	13
Copper	17	1	820	9	17	1	819	9	17	1	819	9
Lead	253	0.2	10908	48	249	0.2	10904	48	249	0.2	10904	48
Mercury	22	22	1100	164	22	22	1100	164	22	22	1100	164
Molybdenum	327202	4837	15451612	11232	325985	4837	15450146	11232	326687	4837	15450993	11232
Nickel	17	309	853	18	17	309	852	18	17	309	852	18
Selenium	186	2	12198	8	175	2	12171	8	176	2	12173	8
Silver	517	2	21670	nd	511	2	21665	nd	511	2	21664	nd
Tin	567	147	26506	1411	567	147	26506	1411	567	147	26506	1411
Vanadium	14	280	650	24	15	280	652	24	15	280	652	24
Zinc	4261	631	341198	31	4195	630	340967	31	4190	630	340949	31
Lowest RMWI	**1**	**0.01**	**51**	**3**	**1**	**0.01**	**51**	**3**	**1**	**0.01**	**51**	**3**

highlighted *COPC that determines the lowest (final) RMWI*

References

Health Canada. 2004. *Canadian Handbook on Health Impact Assessment. Vol. 3: The Multidisciplinary Team*. Ottawa, ON. Health Canada.