APPENDIX 25-C
KSM COUNTRY FOODS SCREENING LEVEL RISK ASSESSMENT FOR THE PTMA

Seabridge Gold Inc.

KSM PROJECT
Country Foods Screening Level Risk Assessment for the Processing and Tailings Management Area

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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 during operation and closure of the Proponent's proposed KSM Project, conducted by Rescan Environmental Services Ltd. This SLRA addresses the Processing and Tailing Management Area, particularly the Tailing Management Facility of the Project. The Mine Site is addressed in a separate SLRA. 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.

The information contained in this SLRA is intended to support the Application for an Environmental Assessment Certificate/Environmental Impact Statement. The purpose of the assessment was to evaluate the operation and closure quality of country foods harvested from the Processing and Tailing Management Area. 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).

The country foods evaluated for this SLRA were moose (*Alces alces*), snowshoe hare (*Lepus americanus*), and grouse (*Phasianidae* sp.); a mixture of berries consisting of highbush cranberry (*Viburnum edule),* huckleberry *(Vaccinium membanaceum),* and blueberry *(V. ovalifolium*); and non-migratory Dolly Varden (*Salvelinus malma malma)*. Dolly Varden residing downstream of the proposed Tailing Management Facility were included in the SLRA for the baseline scenario because they are valued for human consumption; however, health risks during the operation and closure phases were not evaluated because of high uncertainty with bioaccumulation factors in the aquatic food chain. 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 that may be harvested from the region would reflect their long-term exposure to marine environments, rather than their short-term exposure to freshwater environments during their spawning migration.

The SLRA focused on metals because the Project is a proposed metal mine. Fifteen metals were selected for evaluation in this assessment. Metals were selected based on screening of the soil and surface water baseline data collected from the baseline study area for the baseline scenario and on modelled water and sediment quality predictions for the operation and closure scenario of the Tailing Management Facility against the Canadian Council of Ministers of the Environment water quality guidelines (CCME 2010b) and BC maximum water criteria for the protection of freshwater aquatic life (BC MOE 2006). Metal concentrations in foods were modelled for moose, snowshoe hare, and grouse muscle tissue, while berries and fish were collected for laboratory analysis during baseline studies.

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

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1. Introduction

1.1 Overview

This country foods Screening Level Risk Assessment (SLRA) supplements Section 25.3 of the KSM Project's (the Project's) Application for an Environmental Assessment Certificate/ Environmental Impact Statement (Application/EIS). Section 25.3 found that 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 affected soil, vegetation, and water in the Tailing Management Facility (TMF) during operation and closure. The potential effects of the construction phase on country foods are expected to be lower than any effects from the operation and closure phases. Because the inherent nature of a SLRA is to be conservative, the SLRA assessed possible worst-case scenarios; therefore, the construction phase was not included in the assessment. The TMF is not expected to contain vegetation during operation due to the continuous disruption of the TMF surface through the continuous addition of tailing. Thus, there is no risk to moose or grouse from the vegetation ingestion pathway during operation. Vegetation will grow on the TMF during and after closure and may represent an exposure risk due to ingestion by moose, snowshoe hare, and grouse. Concentration of metals in vegetation and in soils will be monitored and an ecological and human health risk assessment will be conducted should concentrations approach trigger levels.

This country foods SLRA presents the predicted risks associated with consuming country foods (moose, snowshoe hare, grouse, berries, and Dolly Varden) harvested at the TMF when the proposed mine is operational (operation scenario) and for five years 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 country foods SLRA was to evaluate the quality of moose, grouse, snowshoe hare, berries, and Dolly Varden that are eaten by harvesters (e.g., guide outfitters, Aboriginal peoples, trappers) 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, berries, and Dolly Varden were compared to those of the operation and closure scenario risks. This SLRA calculated no unacceptable risks to people from consuming these country foods during baseline, operation, and closure scenarios. Based on the measured baseline conditions and the modelled operation/closure conditions, country food quality is not expected to change substantially. Country food harvesters can therefore continue to consume these country foods at the rates and frequencies to which they are accustomed.

1.2 Methodology

The methodology for the screening level human health risk assessment was based on Health Canada's guidelines for assessing food issues in environmental impact assessments (Health Canada 2010a).

The human health risk assessment was divided into the following 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 intakes (TDIs; 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 in the Project area, specifically:

- Identify the most relevant country foods harvested in the Project area 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.
- 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 under the baseline scenario included: moose (*Alces alces*), snowshoe hare (*Lepus americanus*), grouse (*Phasianidae* sp.), and highbush cranberry (*Viburnum edule*). Fish species were not included in the baseline report, but human health risks due to the ingestion of salmon were assessed separately (Appendix 25-B, Memorandum 2010). These species were selected because they were reportedly harvested by the country foods harvesters.

For the operation and closure scenarios, moose, snowshoe hare, and grouse may be exposed to the predicted elevated metal concentrations if they enter the TMF. Animals that enter the TMF and drink the tailing water will be exposed to higher metal concentrations than baseline water. Although tailing ponds provide shallow aquatic habitat, large ungulates, such as moose, are expected to avoid the Project footprint due to habitat loss (Section 18.7.1.3) and sensory disturbance (Section 18.7.3.3) during the operation and closure phases of the Project. However, some studies have shown that ungulates avoid predation by wolves or other predators by remaining close to human activity or infrastructure in some cases (Kittle 2008). Moose may intentionally ingest the tailing as a source of minerals. Although it is unlikely that moose will spend long periods of time in the TMF because of sensory disturbance and habitat loss from mining activity, their presence in the TMF has been assumed as a worst-case scenario. During closure, activity in the TMF may be reduced and partially or fully re-vegetated areas may attract moose. Grouse might consume fine tailing as a source of grit, which is used in their gizzard and crop to grind their food.

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 and the Gitxsan Nation (moose and grouse), Tahltan Nation (moose), and

Gitanyow huwilp, including Gitanyow wilp Wii'litsxw (moose). They would also have direct exposure to tailing, vegetation, and water in the TMF.

Snowshoe hare were not identified as being potentially affected by mine development (Chapter 18, Section 18.5.2), but were included in this assessment as a representative of a small herbivorous mammal important to First Nations and Nisga'a Nation.

Salmon were not identified as being potentially affected by mine development because they are anadromous and reside primarily in marine waters, except during early juvenile life stages and spawning migrations. It is noted that potential impacts to salmon were raised by the Nisga'a Nation and the other Aboriginal groups as a concern during the Proponent's consultation activities. The quality of adult salmon that may be harvested from the region 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 North Treaty Creek and South Teigen Creek were analyzed during baseline studies (Chapter 15). Dolly Varden was selected for tissue analysis because it is a resident species and was found at most monitoring sites, which makes it possible to compare fish tissue quality across multiple sites and conditions. A recommended maximum weekly intake of Dolly Varden of one meal was calculated based on the concentration of aluminum, arsenic, mercury, and selenium in fish tissue (Appendix 25-C of this Appendix). Winter fishing activities in Gitxsan and Skii km Lax Ha asserted territories include fishing for Dolly Varden and trout (e.g., bull trout [*Salvelinus* sp.], cutthroat, and rainbow trout [*Oncorhynchus* sp.; Chapter 30, Appendices 30-B and 30-D]). An assessment of potential Project effects from the consumption of Dolly Varden is included for metals identified as COPCs during screening against federal and provincial guidelines, based on bioconcentration factors calculated from baseline conditions.

2.3 Contaminants of Potential Concern Selected for Evaluation

The proposed Project is a gold/copper mine. Metals occur naturally in the environment as a result of rock weathering and other geological processes. Generating fine tailing from mining may mobilize metals that are sequestered in the ore. During the processing of ore, metals that are not extracted will remain in the tailing or leach into the surrounding water. Metal 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 the 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 exceeded the CCME or British Columbia (BC) water quality guidelines for the protection of aquatic life (BC MOE 2006; CCME 2010b).
3. The metal concentration in the sediment that was modelled in the TMF in the operation and closure scenarios was greater than the CCME or BC sediment quality guidelines for the protection of aquatic life (CCME 2002; BC MOE 2006).
4. The concentration of a metal in the water that was modelled in the TMF in the operation and closure scenarios was greater than the CCME or BC maximum water quality guidelines for the protection of aquatic life.

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 non-metal compound were selected as COPCs for evaluation. These metals were: aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, mercury, molybdenum, nickel, selenium, silver, vanadium, and zinc. The other compound with potential toxicity included in the assessment was fluoride.

Modelled fluoride and nitrate concentrations in the TMF exceeded the BC water quality guidelines during operation and closure in the North and South Cell TMFs. Health Canada provides a toxicity reference value (TRV) for fluoride of 0.105 mg/kg body weight/d (Health Canada 2010b). Fluoride is toxic to freshwater aquatic life and can accumulate permanently in the long bones of vertebrates causing fluorosis when present in excessive amounts. Fluoride was therefore included as a COPC. Nitrate is toxic to ruminants and humans via the formation of methemoglobin, which decreases the oxygen transport capacity of the red blood cells. This effect is most commonly observed with animal diets that are rich in nitrates and with high nitrate concentrations in contaminated drinking water. However, nitrate concentrations harmful to human health will not sufficiently build up in an animal to harmful effect levels. Nitrates are used as food additives to cure and preserve meats. Therefore, nitrate has not been included as a COPC in this assessment.

It is noted that the maximum concentrations of total iron in the surface waters have exceeded the CCME guideline for the protection of freshwater aquatic life; however, there is no soil guideline for iron (CCME 2010a, 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. 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 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 was selected as a COPC due to its potential to bioaccumulate as methylmercury (US EPA 1997) and due to its baseline and predicted exceedance of CCME water quality guidelines for the protection of freshwater aquatic life inside the TMF.

It is also noted that maximum modelled concentrations of sulphate exceeded the CCME water quality guideline (CCME 2010b) for the protection of freshwater aquatic life in the TMF during operation and closure. Despite the exceedance in the TMF, 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 of up to 90 days with no signs of toxicity, except for changes in methaemoglobin and sulfhaemoglobin levels (Digesti and Weeth 1976). Sulphate levels of approximately 2,000 mg/L were modelled for the TMF. However, it is assumed that moose, snowshoe hare, and grouse will not consume TMF water continuously. Sulphate does not bioaccumulate and is used as an additive 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.

Cyanide, although used as a gold lixiviant and therefore elevated in concentration in the TMF, was not included as a COPC in the country foods assessment. Non-lethal doses of cyanide are detoxified in the animal body to thiocyanate and are excreted with the urine usually within 24 hours (ATSDR 2004b). Therefore, cyanide does not build up in the food chain at levels harmful to human health. Although cyanides can be found in fish from contaminated waters, cyanides readily decompose upon heating, and cooked foods contain little or no cyanide (WHO 1984). The TMF will not be stocked with fish after closure and therefore fish are not expected to reside in the TMF. Cyanides were not found to be elevated above BC and CCME (2010b) guidelines for the protection of freshwater aquatic life at locations downstream of the TMF. Cyanide ions in soil are not strongly adsorbed and retained, and numerous micro-organisms are able to degrade free cyanide to carbon dioxide and ammonia (Health Canada 1979). Berries are therefore not expected to take up cyanides from soil or sediments in concentrations harmful to human health.

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 (6 months to 4 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 their 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 (Health Canada 2010c).

Table 2.3-1. Metals Evaluated and Rationale for Inclusion as Contaminants of Potential Concern

	Maximum Soil Concentration[1] mg/kg	CCME Soil Guideline (Agricultural) mg/kg	Mean Rougher Tailing Concentration in TMF mg/kg	CCME Sediment Guideline ISQG mg/kg	BC Sediment Guideline mg/kg	Maximum Water Concentration at Baseline in Teigen and Treaty (STE1[2], STE1A, NTR1, NTR1A, 2007-2011) mg/L (total metals)	Predicted Water Concentration in TMF[3]: Max for Operation years 1-50: North Cell mg/L	Predicted Water Concentration in TMF[3]: Max for Operation years 1-50: CIL mg/L	Predicted Water Concentration in TMF[3]: Max for Operation years 1-50: South Cell mg/L	Predicted Water Concentration in TMF[3]: Max for Closure years 51-65: North Cell mg/L	Predicted Water Concentration in TMF[3]: Max for Closure years 51-65: CIL mg/L	Predicted Water Concentration in TMF[3]: Max for Closure years 51-65: South Cell mg/L	CCME Water Guideline Freshwater Aquatic Life mg/L	BC Max. Water Criteria Freshwater Aquatic Life mg/L	Inclusion in SLRA
Aluminum (Al)	39,300	-	70,979	-	-	1.9	0.767	0.0809	0.602	0.042	0.0376	0.451	0.1	0.1	Y
Antimony (Sb)	15.0	-	2.74	-	-	0.0001	0.00338	0.0166	0.00339	0.0000552	0.00893	0.00337	-	-	N
Arsenic (As)	169	12.0	5.95	5.9	5.9	0.0007	0.0459	0.0133	0.0369	0.0000503	0.00623	0.0278	0.005	0.005	Y
Barium (Ba)	1,110	750	2,443	-	-	0.04	0.412	0.0658	0.329	0.0121	0.0305	0.247	-	-	Y
Beryllium (Be)	6.47	4	0.943	-	-	0.0003	0.000684	0.000318	0.000564	0.000207	0.000164	0.000453	-	-	Y
Bismuth (Bi)	10.0	-	5.17	-	-	0.0003	-	-	-	-	-	-	-	-	N
Cadmium (Cd)	1.52	1.4	0.319	0.6	0.6	0.0001	0.0000629	0.000133	0.0000547	0.00000658	0.0000712	0.0000459	0.000043-0.00034[4]	-	Y
Calcium (Ca)	16,000	-	11,876	-	-	38.6	300	300	300	12.9	275	300	-	-	N
Chromium (Cr)	288	64	30.4	37.3	37.3	0.007	0.00548	0.000742	0.00438	0.000222	0.000368	0.0033	0.0089	-	Y
Cobalt (Co)	123	40	14.2	-	-	0.001	0.00318	0.0118	0.00302	0.0000445	0.00632	0.00278	-	0.11	Y
Copper (Cu)	1,060	63	382	35.7	35.7	0.0052	0.00743	0.0614	0.00754	0.000570	0.0334	0.00827	0.0076-0.036[4]	0.015-0.080[4]	Y
Iron (Fe)	373,000	-	33,288	ng	21,200	2.1	0.0590	0.0215	0.033	0.0330	0.0119	0.0271	0.3	1	N
Lead (Pb)	69.0	70	23.5	35	35	0.0005	0.00109	0.000201	0.000866	0.0000278	0.0000908	0.000651	0.0046-0.047[4]	1.12-1.21[4]	N
Lithium (Li)	55.4	-	13.6	-	-	0.0025	0.0287	0.0181	0.0235	0.00208	0.00926	0.0182	-	-	N
Magnesium (Mg)	30,500	-	9,479	-	-	10.1	19.1	9.75	15.4	2.77	4.93	12.0	-	-	N
Manganese (Mn)	13,200	-	709	-	-	0.06	0.169	0.0475	0.133	0.00876	0.0221	0.0999	-	0.69-1.45[4]	N
Mercury (Hg)	2.72	6.6	0.0599	0.2	0.2	0.00003	0.000269	0.00003	0.000214	0.00000430	0.0000136	0.00016	0.000026	-	Y
Molybdenum (Mo)	154	5	8.11	-	-	0.0007	0.247	0.207	0.204	0.000277	0.108	0.158	0.073	2	Y
Nickel (Ni)	120	50	396	-	16	0.0069	0.00584	0.00381	0.00474	0.000575	0.00199	0.00369	0.12-0.47[4]	-	Y
Phosphorus (P)	8,510	-	1,294	-	-	0.15							-	-	N
Potassium (K)	4,060	-	34,603	-	-	0.69							-	-	N
Selenium (Se)	10.8	1	5.44	-	5	0.0016	0.0542	0.0527	0.0451	0.000431	0.0276	0.0351	0.001	-	Y
Silver (Ag)	5.00	20	0.847	-	0.5	0.00003	0.000113	0.0000842	0.0000929	0.00000430	0.0000438	0.0000721	0.0001	0.003	Y
Sodium (Na)	4,650	-	4,482	-	-	3.1							-	-	N
Strontium (Sr)	270	-	174	-	-	0.4							-	-	N
Thallium (Tl)	0.50	1	2.05	-	-	0.00005	0.000295	0.0000549	0.000235	0.0000412	0.0000302	0.00018	0.0008	-	N
Tin (Sn)	21.3	5	6.21	-	-	0.00005							-	-	N
Titanium (Ti)	6,760	-	1,917	-	-	0.061							-	-	N
Vanadium (V)	351	130	180	-	-	0.0055	0.0270	0.00451	0.0216	0.000430	0.00203	0.0162	-	-	Y
Zinc (Zn)	236	200	120	123	123	0.010	0.0282	0.0257	0.0236	0.000946	0.0135	0.0185	0.03	0.067-0.588[4]	Y
WAD-Cyanide (WAD-CN)	nd	-	nd	-	-	0.0005	0.0465	0.455	0.0505	0.000457	0.247	0.0555	-	0.01	N
Fluoride (F)	nd	-	nd	-	-	0.047	9.42	1.05	7.50	0.0222	0.443	5.59	0.12	1.45-2.18[4]	Y
Nitrate (NO3)	nd	-	nd	-	-	1.170	76.3	7.51	62.3	0.0758	3.14	45.5	2.935	32.8	N
Sulphate (SO4)	nd	-	nd	-	-	95.800	2,280	1,620	1,870	27.1	832	1,440	-	100	N

Notes:
- = no guideline
nd = not determined
CIL = CIL lined pond
WAD = weak acid dissociable
[1] Maximum soil concentration in 0-10 cm, n=59 (2009)
[2] High outlier STE1A, September 4, 2011, excluded
[3] Maximum of modelled monthly predictions using the mean water quality data as source term and assuming normal flow
[4] Guideline is hardness-dependent and applicable range is provided
Highlighted numbers indicate guideline exceedance

2.5 Human Exposure Pathways

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

Tailing water and sediment are predicted to contain elevated metal concentrations in the TMF. Moose, snowshoe hare, and grouse that drink the water and ingest tailing may be exposed to these COPCs. The bulk of the soil ingested by herbivores comes from the roots of consumed vegetation. Because no vegetation would be growing directly from the tailing during the operation, moose will likely consume a small percent of tailing from the TMF. The tailing ingestion would probably result in moose attempting to obtain salts and minerals from the sediment. During closure, moose, snowshoe hare, and grouse may obtain vegetation from re-vegetated areas of the TMF. Therefore, uptake of COPCs by plant roots into the above-ground tissue was modelled using bioconcentration factors (BCF) from the literature (Staven et al. 2003; US EPA 2005). A fraction of the ingested metals would be absorbed and retained in the muscle tissue of these animals. Human receptors that eat moose, snowshoe hare, or grouse that have entered the TMF will be indirectly exposed to COPCs originating from the TMF. Human exposures may result even if people do not physically enter the PTMA because animals will travel outside of the Project area.

Subsequently, this assessment is based on human ingestion of:

- moose (who have accumulated metals from the TMF from drinking the water, and/or from consuming tailing on the ground as a source of salt, and/or from incidentally ingesting the tailing, and/or from ingesting plants established on the TMF during closure);
- snowshoe hare (who have accumulated metals from the TMF from drinking the water, and/or incidentally ingesting the tailings, and/or ingesting plants established on the TMF during closure);
- grouse (who have accumulated metals from the TMF through drinking the water in the TMF, and/or consuming tailing on the ground as grit, and/or consuming vegetation established on the TMF); and
- Dolly Varden in North Treaty Creek and South Teigen Creek (who have accumulated metals downstream of the TMF from water) and by inference Dolly Varden which reside in the mainstems of Treaty and Teigen creeks.

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) from the TMF and surrounding Project area;
- the concentration of COPCs in berries; and
- human receptor characteristics (e.g., consumption amount, frequency, and body weight).

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

3.2 Country Food Contaminants of Potential Concern 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 the conditions modelled during the operation and closure periods. The COPC concentrations in moose, snowshoe hare, and grouse tissue also depended on the animal's consumption rates of these media. The food chain model and results are presented in Appendix A. Table 3.2-1 summarizes the modelled COPC concentration in moose, snowshoe hare, and grouse tissue under baseline, operation, and closure scenarios.

3.3 Fish Tissue Concentrations

Measurements of fish tissue metals were available for Dolly Varden from 2008 to 2011. The details of the sampling methods and sampling locations are presented in Appendix 15-B, 2008 Baseline Study Report-Aquatic Ecology. Fish were collected in North Treaty Creek (n=13) and South Teigen Creek (n=16). Concentrations of some COPCs in fish tissues varied considerably between the two sites reflecting the different habitat conditions in the different watersheds. Therefore, to assess human exposures to COPCs in fish tissues, sites were treated separately. Table 3.3-1 presents the mean metal concentrations of COPCs from the 2008 to 2011 Dolly Varden tissue sampling in North Treaty Creek and South Teigen Creek.

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

COPC	Moose			Grouse			Snowshoe Hare		
	Baseline	Operation	Closure	Baseline	Operation	Closure	Baseline	Operation	Closure
Aluminum (Al)	7.2	10.2	10.2	1687	1801	1801	0.167	0.167	0.188
Arsenic (As)	0.0199	0.0147	0.0146	3.8	3.7	3.7	0.0005	0.0005	0.0004
Barium (Ba)	0.0219	0.0370	0.0501	0.26	0.32	0.32	0.0004	0.0004	0.0005
Beryllium (Be)	0.0006	0.0006	0.0005	0.0560	0.0546	0.0546	0.000011	0.000011	0.000010
Cadmium (Cd)	0.0001	0.0001	0.0001	0.0063	0.0062	0.0061	0.000001	0.000001	0.000001
Chromium (Cr)	0.1001	0.0787	0.0783	1.6	1.5	1.5	0.0023	0.0023	0.0021
Cobalt (Co)	0.0746	0.0616	0.0608	5.9	5.7	5.7	0.0016	0.0016	0.0015
Copper (Cu)	0.57	0.59	3.28	12.6	12.7	12.9	0.0126	0.0126	0.0216
Mercury (Hg)	0.0013	0.0010	0.0016	0.0016	0.0015	0.0015	0.00003	0.00003	0.00003
Molybdenum (Mo)	0.0071	0.0072	0.0072	0.55	0.53	0.53	0.0002	0.0002	0.0002
Nickel (Ni)	0.0866	0.18	0.23	0.0041	0.0053	0.0053	0.0016	0.0016	0.0025
Selenium (Se)	0.0035	0.0046	0.0042	0.33	0.33	0.33	0.0001	0.0001	0.0001
Silver (Ag)	0.0011	0.0009	0.0009	0.35	0.34	0.34	0.00003	0.00003	0.00002
Vanadium (V)	0.0676	0.0684	0.21	0.0037	0.0037	0.0037	0.0016	0.0016	0.0021
Zinc (Zn)	0.0086	0.0085	0.0371	0.0842	0.0839	0.0876	0.0001	0.0001	0.0002
Fluoride (F)	0.13	7.8	2.6	0.0000	0.0003	0.0001	0.0007	0.0007	0.0046

Table 3.3-1. Mean Total Metal Concentrations Measured and Modelled in Dolly Varden Muscle Tissue (mg/kg wet weight) from North Treaty Creek and South Teigen Creek

COPC (Total)	Maximum Tissue Concentration (mg/kg wwt)					
	Baseline		Operation		Closure	
	North Treaty	South Teigen	North Treaty	South Teigen	North Treaty	South Teigen
	n=13	n=16	Predicted based on Modelled Water Quality			
Aluminum	103	324	92.2	140	92.2	143
Arsenic	0.1	0.119	0.723	0.112	0.723	0.113
Barium	2.22	4.6	1.64	1.91	1.66	2.12
Beryllium	0.05	0.05	0.0766	0.0576	0.0717	0.0699
Cadmium	0.123	0.055	0.0917	0.0129	0.0917	0.0137
Chromium	1.06	1.93	1.08	1.83	1.08	1.85
Cobalt	0.255	0.405	0.286	0.563	0.296	0.582
Copper	1.11	1.36	2.02	1.87	2.07	1.91
Mercury	0.037	0.196	nd	nd	nd	nd
Molybdenum	0.031	0.174	0.0321	0.062	0.109	0.0628
Nickel	0.55	1.23	0.492	0.756	0.492	0.767
Selenium	2.65	2.06	nd	nd	nd	nd
Silver	nd	nd	nd	nd	nd	nd
Vanadium	0.37	1.19	0.257	0.507	0.257	0.507
Zinc	39.6	46.6	54.8	60.1	54.8	64.1
Fluoride	nd	nd	nd	nd	nd	nd

Notes:
nd = not determined
wwt = wet weight

3.4 Plant Tissue Concentrations

Leafs of berries (*Vaccinium membranaceum* and *V. ovalifolium*, n=19), raspberries (*Rubus idaeus*, n=10), Sitka valerian (*Valeriana sitchensis*, n=4), and willows (*Salix* ssp., n=3), as well as fruit of *Viburnum edule* (highbush cranberry, n=3) and *V. ovalifolium* (blueberry, n=5) were collected within the PTMA in the summers of 2008 and 2009 and were analyzed for metal concentrations (Table 3.4-1; Rescan 2010b). Raw results of the laboratory analysis are presented in Chapter 17, Terrestrial Ecosystems; and Appendix 17-A, KSM Project 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, grouse, snowshoe hare; see Appendix A to this SLRA). The average of the berry data alone were used to calculate the direct exposure to people who consume local berries.

Table 3.4-1. Total Metal Concentrations Measured in Vegetation and Berry Tissue (mg/kg wet weight) near the Processing and Tailing Management Area

COPC	Vegetation[1] Concentration, 95% UCLM (n = 44)	Berry[2] Concentration, 95% UCLM (n = 8)
Aluminum (Al)	31.3	13.2
Arsenic (As)	0.0089	0.0067
Barium (Ba)	8.69	2.50
Beryllium (Be)	0.0334	0.0438
Cadmium (Cd)	0.0498	0.0040
Chromium (Cr)	0.151	0.097
Cobalt (Co)	0.117	0.017
Copper (Cu)	1.003	0.960
Mercury (Hg)	0.001960	0.000526
Molybdenum (Mo)	0.0547	0.0871
Nickel (Ni)	0.577	0.228
Selenium (Se)	0.093	0.103
Silver (Ag)	-	-
Vanadium (V)	0.0568	0.0515
Zinc (Zn)	7.72	1.64
Fluoride (F)	-	-

Notes:
[1] Vegetation samples represent *Vaccinium membranaceum and V. ovalifolium, Rubus idaeus*., *Salix* ssp., and *Valeriana sitchensis.*
[2] Berry samples represent blueberry (*Vaccinium ovalifolium*) and highbush cranberry (*Viburnum edule*).
- = not determined
UCLM = upper confidence limit of the mean
N = sample number

3.5 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-wwt/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 3.5-1 presents a summary of the human receptor characteristics. The body weights for adults and toddlers were based on guidance provided by Health Canada (2010a). Receptor characteristics were based on guidance provided by Health Canada (2010a) and on 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 area (Table 3.5-1). Data from the Jin (2006) interviews 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 the *Compendium for Canadian Human Exposure Factors for Risk Assessment* (Richardson 1997). It is anticipated that this assumption overestimates the actual toddler serving sizes. The assumed receptor characteristics are presented in Table 3.5-1.

Table 3.5-1. Human Receptor Characteristics

Body Weight	**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

3.6 Estimated Daily Intake

The EDI of each COPC for toddlers and adults was based on the predicted (moose, grouse, snowshoe hare) and measured (fish, 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 is presented in Table 3.6-1. For this assessment, it was assumed that 100% of the country foods were harvested from the Project area and that 100% of the COPCs were bioavailable; assumptions that are not entirely possible, and therefore provide a highly conservative estimate. Appendix B presents a sample calculation of the EDI of aluminum for toddlers consuming moose tissue for the baseline scenario.

Estimated daily intakes of COPCs from salmon were not evaluated because the quality of adult salmon that may be harvested from the area would reflect their long-term exposure to marine environments rather than their short-term exposure to freshwater environments during their spawning migration.

Table 3.6-1. Estimated Daily Intake of Contaminants of Potential Concern by Human Receptors (mg/kg body weight/day)

	Estimated Daily Intake of COPC (mg/kg BW) by Adult Receptor														
	Baseline					Operation					Closure				
COPC	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden
Aluminum (Al)	2.18E-02	1.17E-01	6.74E-06	1.72E-03	7.80E-03	3.07E-02	1.25E-01	6.74E-06	1.72E-03	2.02E-03	3.06E-02	1.25E-01	7.62E-06	1.72E-03	1.62E-02
Arsenic (As)	5.99E-05	2.66E-04	1.92E-08	8.78E-07	7.57E-06	4.40E-05	2.54E-04	1.92E-08	8.78E-07	9.46E-06	4.38E-05	2.54E-04	1.75E-08	8.78E-07	5.81E-05
Barium (Ba)	6.57E-05	1.80E-05	1.43E-08	3.25E-04	1.68E-04	1.11E-04	2.25E-05	1.43E-08	3.25E-04	8.31E-05	1.50E-04	2.26E-05	2.05E-08	3.25E-04	2.47E-04
Beryllium (Be)	1.88E-06	3.90E-06	4.27E-10	5.71E-06	3.78E-06	1.74E-06	3.80E-06	4.27E-10	5.71E-06	4.69E-06	1.43E-06	3.79E-06	3.99E-10	5.71E-06	9.36E-06
Cadmium (Cd)	2.19E-07	4.41E-07	3.93E-11	5.22E-07	9.31E-06	2.11E-07	4.28E-07	3.93E-11	5.22E-07	2.13E-06	1.77E-07	4.27E-07	3.69E-11	5.22E-07	7.29E-06
Chromium (Cr)	3.01E-04	1.08E-04	9.22E-08	1.27E-05	8.02E-05	2.36E-04	1.05E-04	9.22E-08	1.27E-05	2.63E-05	2.35E-04	1.05E-04	8.57E-08	1.27E-05	2.03E-04
Cobalt (Co)	2.24E-04	4.10E-04	6.58E-08	2.22E-06	1.93E-05	1.85E-04	3.97E-04	6.58E-08	2.22E-06	9.86E-06	1.83E-04	3.97E-04	6.17E-08	2.22E-06	5.91E-05
Copper (Cu)	1.73E-03	8.79E-04	5.08E-07	1.25E-04	8.40E-05	1.76E-03	8.82E-04	5.08E-07	1.25E-04	6.98E-05	9.85E-03	8.96E-04	8.73E-07	1.25E-04	2.70E-04
Mercury (Hg)	4.00E-06	1.11E-07	1.18E-09	6.85E-08	2.27E-06	3.02E-06	1.06E-07	1.18E-09	6.85E-08	nd	4.92E-06	1.06E-07	1.17E-09	6.85E-08	nd
Molybdenum (Mo)	2.12E-05	3.81E-05	6.52E-09	1.13E-05	2.80E-06	2.14E-05	3.65E-05	6.52E-09	1.13E-05	2.26E-06	2.15E-05	3.65E-05	6.21E-09	1.13E-05	6.56E-06
Nickel (Ni)	2.60E-04	2.87E-07	6.54E-08	2.97E-05	2.35E-06	5.56E-04	3.69E-07	6.54E-08	2.97E-05	1.45E-05	7.03E-04	3.70E-07	1.01E-07	2.97E-05	8.70E-05
Selenium (Se)	1.05E-05	2.26E-05	2.23E-09	1.34E-05	4.16E-05	1.20E-05	2.30E-05	2.23E-09	1.34E-05	nd	1.26E-05	2.30E-05	2.32E-09	1.34E-05	nd
Silver (Ag)	3.36E-06	2.42E-05	1.08E-09	nd	2.01E-04	2.65E-06	2.34E-05	1.08E-09	nd	nd	2.65E-06	2.34E-05	1.01E-09	nd	nd
Vanadium (V)	2.03E-04	2.58E-07	6.45E-08	6.70E-06	1.89E-06	2.06E-04	2.58E-07	6.45E-08	6.70E-06	7.58E-06	6.32E-04	2.59E-07	8.38E-08	6.70E-06	5.32E-05
Zinc (Zn)	2.57E-05	5.85E-06	4.63E-09	2.14E-04	2.80E-05	2.56E-05	5.84E-06	4.63E-09	2.14E-04	1.79E-03	1.11E-04	6.09E-06	8.46E-09	2.14E-04	8.00E-03
Fluoride (F)	3.89E-04	2.35E-09	2.72E-08	nd	3.00E-03	2.21E-02	2.26E-08	2.72E-08	nd	nd	7.61E-03	9.11E-09	1.83E-07	nd	nd

	Estimated Daily Intake of COPC (mg/kg BW) by Toddler Receptor														
	Baseline					Operation					Closure				
COPC	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden
Aluminum (Al)	4.01E-02	2.16E-01	1.24E-05	3.18E-03	1.44E-02	5.66E-02	2.31E-01	1.24E-05	3.18E-03	8.90E-03	5.65E-02	2.31E-01	1.40E-05	3.18E-03	1.64E-02
Arsenic (As)	1.10E-04	4.90E-04	3.53E-08	1.62E-06	1.39E-05	8.11E-05	4.68E-04	3.53E-08	1.62E-06	3.16E-05	8.06E-05	4.68E-04	3.22E-08	1.62E-06	5.82E-05
Barium (Ba)	1.21E-04	3.32E-05	2.63E-08	5.99E-04	3.10E-04	2.05E-04	4.14E-05	2.63E-08	5.99E-04	1.43E-04	2.77E-04	4.16E-05	3.78E-08	5.99E-04	2.63E-04
Beryllium (Be)	3.47E-06	7.18E-06	7.87E-10	1.05E-05	6.97E-06	3.21E-06	7.00E-06	7.87E-10	1.05E-05	5.35E-06	2.64E-06	6.99E-06	7.35E-10	1.05E-05	9.86E-06
Cadmium (Cd)	4.04E-07	8.12E-07	7.23E-11	9.62E-07	1.72E-05	3.89E-07	7.89E-07	7.23E-11	9.62E-07	3.98E-06	3.27E-07	7.88E-07	6.80E-11	9.62E-07	7.34E-06
Chromium (Cr)	5.54E-04	2.00E-04	1.70E-07	2.34E-05	1.48E-04	4.35E-04	1.93E-04	1.70E-07	2.34E-05	1.11E-04	4.33E-04	1.93E-04	1.58E-07	2.34E-05	2.04E-04
Cobalt (Co)	4.13E-04	7.56E-04	1.21E-07	4.09E-06	3.56E-05	3.41E-04	7.31E-04	1.21E-07	4.09E-06	3.32E-05	3.36E-04	7.31E-04	1.14E-07	4.09E-06	6.12E-05
Copper (Cu)	3.18E-03	1.62E-03	9.35E-07	2.30E-04	1.55E-04	3.25E-03	1.63E-03	9.35E-07	2.30E-04	1.50E-04	1.82E-02	1.65E-03	1.61E-06	2.30E-04	2.77E-04
Mercury (Hg)	7.37E-06	2.05E-07	2.18E-09	1.26E-07	4.18E-06	5.57E-06	1.95E-07	2.18E-09	1.26E-07	nd	9.06E-06	1.95E-07	2.15E-09	1.26E-07	nd
Molybdenum (Mo)	3.91E-05	7.02E-05	1.20E-08	2.09E-05	5.16E-06	3.94E-05	6.73E-05	1.20E-08	2.09E-05	6.50E-06	3.97E-05	6.74E-05	1.14E-08	2.09E-05	1.20E-05
Nickel (Ni)	4.80E-04	5.29E-07	1.21E-07	5.48E-05	4.32E-06	1.02E-03	6.80E-07	1.21E-07	5.48E-05	4.76E-05	1.30E-03	6.81E-07	1.87E-07	5.48E-05	8.77E-05
Selenium (Se)	1.93E-05	4.17E-05	4.10E-09	2.47E-05	7.67E-05	2.22E-05	4.24E-05	4.10E-09	2.47E-05	nd	2.32E-05	4.24E-05	4.28E-09	2.47E-05	nd
Silver (Ag)	6.19E-06	4.45E-05	1.99E-09	nd	3.70E-04	4.87E-06	4.30E-05	1.99E-09	nd	nd	4.87E-06	4.30E-05	1.86E-09	nd	nd
Vanadium (V)	3.74E-04	4.75E-07	1.19E-07	1.23E-05	3.49E-06	3.79E-04	4.75E-07	1.19E-07	1.23E-05	2.89E-05	1.16E-03	4.78E-07	1.54E-07	1.23E-05	5.32E-05
Zinc (Zn)	4.73E-05	1.08E-05	8.54E-09	3.94E-04	5.16E-05	4.72E-05	1.08E-05	8.54E-09	3.94E-04	4.49E-03	2.05E-04	1.12E-05	1.56E-08	3.94E-04	8.28E-03
Fluoride (F)	7.17E-04	4.34E-09	5.01E-08	nd	5.52E-03	4.07E-02	4.17E-08	5.01E-08	nd	nd	1.40E-02	1.68E-08	3.38E-07	nd	nd

Notes:
nd = not determined
Highlighted numbers denote country food with highest estimated daily intake for an adult or toddler 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 (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 (i.e., United States Environmental Protection Agency's [US EPA] Integrated Risk Information System [IRIS], and the Food and Agriculture Organization of the United Nations/World Health Organization Joint Expert Committee on Food Additives and Contaminants [JECFA]). Additional TRVs were obtained from US EPA and from 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 (e.g., 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. 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 4.2 of this Appendix. Health Canada guidelines were used preferentially unless they were not available for certain COPCs, in which case US EPA guidelines were used.

4.2 Toxicity Reference Values

4.2.1 Aluminum

Neither the US EPA or Health Canada have derived an RfD or TDI for aluminum. JECFA provides an estimate for a provisional tolerable weekly intake (PTWI) of 7 mg/kg BW (ATSDR 2008a) and has derived an intermediate-duration and a chronic-duration oral minimal risk level (MRL) of 1 mg Al/kg/day for aluminum. The chronic-duration MRL is based on a lowest observable adverse effects limit (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 2 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.

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

COPCs	TRV (mg/kg BW/d) Adult	TRV (mg/kg BW/d) Toddler	COPCs	TRV (mg/kg BW/d) Adult	TRV (mg/kg BW/d) Toddler
Aluminum	1[a]	1[a]	Mercury	0.0003	0.0003
Arsenic	0.0003	0.0003	Molybdenum	28	23
Barium	0.2	0.2	Nickel	0.011	0.011
Beryllium	0.002[b]	0.002[b]	Selenium	0.0057	0.62
Cadmium	0.0010	0.0010	Silver	0.005[b]	0.005[b]
Chromium	0.001	0.001	Vanadium	0.009[b]	0.009[b]
Cobalt	0.001[c]	0.001[c]	Zinc	0.57	0.48
Copper	0.141	0.091	Fluoride	0.105	0.105
Lead	0.0036	0.0036			

Notes:
[a] ATSDR (2008b)
[b] US EPA (2012)
[c] ATSDR (2004a)
All others from Health Canada (2010b)

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 assessment 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 2002).

4.2.3 Barium

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, and 3 for database deficiencies).

4.2.4 Beryllium

US EPA's IRIS 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 (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 (2010b) and IRIS (US EPA 2012) provide a TDI of 1 µg/kg BW/day for oral exposures to cadmium based on recommendations by the JECFA (1972, 2005).

4.2.6 Chromium

Health Canada (2010b) provides a TDI of 0.001 mg/kg BW/day for total chromium. The TDI for total chromium was selected for use because hexavalent (VI) 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 (US EPA 2012), which was derived from a chronic toxicity study (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 effect 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 (RfC) 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 (2010b) is currently reviewing a TDI for lead. Previously, a provisional TDI of 3.6 µg/kg BW/day for lead based on the PTWI of 25 µg/kg BW recommended by 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, JECFA 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 2010b) 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 prepared by Health Canada. The Health Canada Chemical Health Hazard Assessment Division guideline of 0.71 µg/kg BW/day (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; 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 (i.e., children and women who are pregnant or who are of child-bearing age). This was also adopted by Health Canada (2010b).

For fish, mercury was assumed to be present 100% as methylmercury (Health Canada 2007). Because 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, grouse, snowshoe hare, and plant tissues, mercury was compared to the 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 2010b) 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 BW/day for reproductive effects in rats, with an uncertainty factor of 30.

4.2.12 Nickel

(Health Canada 2010b) provides a TDI of 25 µg/kg BW/day for nickel. 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 2010b) provides an age- and body weight-adjusted tolerable upper limit for selenium of 0.0057 to 0.0062 mg/person/day (adult and toddler, respectively). 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, the critical effect in humans ingesting silver, is 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 Vanadium

US EPA's IRIS provides an oral RfD of 0.009 mg/kg BW/day based on a lower dose level (17.9 ppm [(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 ppm vanadium (about 17.9 or 179 ppm 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.

4.2.16 Zinc

Health Canada (2010b) provides a TDI of 700 µg/kg BW/day. This value was based on the upper safe level established by the Expert Group on Vitamins and Minerals (EVM 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 2 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.

4.2.17 Fluoride

Health Canada (2010b) provides an oral TDI of 0.105 mg/kg BW/day. This TDI was based on epidemiological studies of dental fluorosis, where moderate dental fluorosis was used as an adverse effects endpoint, based on its potential cosmetic concern. By protecting against a cosmetic effect of moderate dental fluorosis, Canadians are also protected against the adverse health effects of severe dental fluorosis and skeletal fluorosis. Low levels of fluoride occur naturally in the environment and often in drinking water and provide dental health benefits.

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 (ER) 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, and were calculated as:

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

For the purpose of a SLRA for non-carcinogenic COPCs in foods, Health Canada (2010a) indicated that an exposure ratio of 0.2 is the maximum acceptable exposure that will not be associated with health risks. 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 that may require a more detailed evaluation.

Table 5.2-1 presents the calculated ERs based on the predicted wildlife concentrations and measured fish and berries concentrations. For snowshoe hare, berries, and Dolly Varden, all ERs were at or below 0.2 for baseline, 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: 0.22-1.63) for adults and toddlers for all three scenarios evaluated. The ER for aluminum for toddlers was also slightly above 0.2 (0.23) for baseline, operation, and closure.

5.3 Estimation of Cancer Risks

For carcinogenic chemicals, risks are calculated as ILCR (over and above background cancer risks), which represents the increased risk of an individual developing cancer in his or her lifetime attributable to 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):

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

For the estimated lifetime daily exposure, measured and predicted 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, grouse, and Dolly Varden used in this assessment appear to be associated with a higher incremental lifetime cancer risk (ranges from 1.4×10^{-5} for Dolly Varden to 4.8×10^{-4} for grouse). 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). All three exposure scenarios (baseline, operation, and closure) have similar ILCRs associated with them. The exceedance of 1×10^{-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).

5.4 Recommended Maximum Weekly Intakes

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

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

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)

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, and grouse by dividing the RMWI by the serving size, based on the survey conducted by Jin (2006). The RMWIs and recommended number of servings for the operation and closure scenarios are very similar to those of the baseline scenario. This similarity is largely attributable to the limited time that moose, grouse, and snowshoe hare are expected to spend in the TMF, compared with more favourable habitat and forage in the surrounding area. People are assumed to only collect berries outside the PTMA, and therefore the RMWI does not change between scenarios. The RMWI of Dolly Varden decreases slightly from baseline, but remains above the currently estimated weekly number of servings.

Table 5.2-1. Exposure Ratios for Human Receptors

	Exposure Ratio for Adult Receptor														
	Baseline					Operation					Closure				
COPC	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden
Aluminum (Al)	2.18E-02	1.17E-01	6.74E-06	1.72E-03	7.80E-03	3.07E-02	1.25E-01	6.74E-06	1.72E-03	8.78E-03	3.06E-02	1.25E-01	7.62E-06	1.72E-03	8.90E-03
Arsenic (As)	2.00E-01	8.87E-01	6.39E-05	2.93E-03	2.52E-02	1.47E-01	8.47E-01	6.39E-05	2.93E-03	1.05E-01	1.46E-01	8.47E-01	5.82E-05	2.93E-03	1.05E-01
Barium (Ba)	3.29E-04	9.01E-05	7.14E-08	1.62E-03	8.40E-04	5.56E-04	1.12E-04	7.14E-08	1.62E-03	6.70E-04	7.52E-04	1.13E-04	1.03E-07	1.62E-03	7.13E-04
Beryllium (Be)	9.42E-04	1.95E-03	2.14E-07	2.85E-03	1.89E-03	8.71E-04	1.90E-03	2.14E-07	2.85E-03	2.54E-03	7.16E-04	1.90E-03	2.00E-07	2.85E-03	2.68E-03
Cadmium (Cd)	2.19E-04	4.41E-04	3.93E-08	5.22E-04	9.31E-03	2.11E-04	4.28E-04	3.93E-08	5.22E-04	3.96E-03	1.77E-04	4.27E-04	3.69E-08	5.22E-04	3.98E-03
Chromium (Cr)	3.01E-01	1.08E-01	9.22E-05	1.27E-02	8.02E-02	2.36E-01	1.05E-01	9.22E-05	1.27E-02	1.10E-01	2.35E-01	1.05E-01	8.57E-05	1.27E-02	1.11E-01
Cobalt (Co)	2.24E-01	4.10E-01	6.58E-05	2.22E-03	1.93E-02	1.85E-01	3.97E-01	6.58E-05	2.22E-03	3.21E-02	1.83E-01	3.97E-01	6.17E-05	2.22E-03	3.32E-02
Copper (Cu)	1.22E-02	6.23E-03	3.60E-06	8.86E-04	5.96E-04	1.25E-02	6.25E-03	3.60E-06	8.86E-04	1.04E-03	6.99E-02	6.35E-03	6.19E-06	8.86E-04	1.07E-03
Mercury (Hg)	1.33E-02	3.70E-04	3.94E-06	2.28E-04	4.83E-03	1.01E-02	3.53E-04	3.94E-06	2.28E-04	nd	1.64E-02	3.54E-04	3.89E-06	2.28E-04	nd
Molybdenum (Mo)	7.57E-07	1.36E-06	2.33E-10	4.05E-07	1.00E-07	7.63E-07	1.30E-06	2.33E-10	4.05E-07	1.27E-07	7.69E-07	1.31E-06	2.22E-10	4.05E-07	2.32E-07
Nickel (Ni)	2.37E-02	2.61E-05	5.95E-06	2.70E-03	2.13E-04	5.05E-02	3.35E-05	5.95E-06	2.70E-03	4.29E-03	6.39E-02	3.36E-05	9.22E-06	2.70E-03	4.33E-03
Selenium (Se)	1.83E-03	3.97E-03	3.91E-07	2.35E-03	7.30E-03	2.11E-03	4.04E-03	3.91E-07	2.35E-03	nd	2.21E-03	4.04E-03	4.08E-07	2.35E-03	nd
Silver (Ag)	6.71E-04	4.83E-03	2.16E-07	nd	4.01E-02	5.29E-04	4.67E-03	2.16E-07	nd	nd	5.29E-04	4.67E-03	2.01E-07	nd	nd
Vanadium (V)	2.26E-02	2.86E-05	7.16E-06	7.45E-04	2.10E-04	2.28E-02	2.87E-05	7.16E-06	7.45E-04	3.21E-03	7.02E-02	2.88E-05	9.31E-06	7.45E-04	3.21E-03
Zinc (Zn)	4.51E-05	1.03E-05	8.13E-09	3.75E-04	4.91E-05	4.50E-05	1.02E-05	8.13E-09	3.75E-04	7.62E-03	1.95E-04	1.07E-05	1.48E-08	3.75E-04	7.88E-03
Fluoride (F)	3.71E-03	2.24E-08	2.59E-07	nd	2.85E-02	2.10E-01	2.16E-07	2.59E-07	nd	nd	7.25E-02	8.68E-08	1.75E-06	nd	nd
	Exposure Ratio for Toddler Receptor														
	Baseline					Operation					Closure				
COPC	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden
Aluminum (Al)	4.01E-02	2.16E-01	1.24E-05	3.18E-03	1.44E-02	5.66E-02	2.31E-01	1.24E-05	3.18E-03	1.62E-02	5.65E-02	2.31E-01	1.40E-05	3.18E-03	1.64E-02
Arsenic (As)	3.68E-01	1.63E+00	1.18E-04	5.39E-03	4.65E-02	2.70E-01	1.56E+00	1.18E-04	5.39E-03	1.94E-01	2.69E-01	1.56E+00	1.07E-04	5.39E-03	1.94E-01
Barium (Ba)	6.05E-04	1.66E-04	1.31E-07	2.99E-03	1.55E-03	1.02E-03	2.07E-04	1.31E-07	2.99E-03	1.23E-03	1.39E-03	2.08E-04	1.89E-07	2.99E-03	1.31E-03
Beryllium (Be)	1.74E-03	3.59E-03	3.94E-07	5.26E-03	3.49E-03	1.61E-03	3.50E-03	3.94E-07	5.26E-03	4.68E-03	1.32E-03	3.50E-03	3.68E-07	5.26E-03	4.93E-03
Cadmium (Cd)	4.04E-04	8.12E-04	7.23E-08	9.62E-04	1.72E-02	3.89E-04	7.89E-04	7.23E-08	9.62E-04	7.29E-03	3.27E-04	7.88E-04	6.80E-08	9.62E-04	7.34E-03
Chromium (Cr)	5.54E-01	2.00E-01	1.70E-04	2.34E-02	1.48E-01	4.35E-01	1.93E-01	1.70E-04	2.34E-02	2.03E-01	4.33E-01	1.93E-01	1.58E-04	2.34E-02	2.04E-01
Cobalt (Co)	4.13E-01	7.56E-01	1.21E-04	4.09E-03	3.56E-02	3.41E-01	7.31E-01	1.21E-04	4.09E-03	5.91E-02	3.36E-01	7.31E-01	1.14E-04	4.09E-03	6.12E-02
Copper (Cu)	3.50E-02	1.78E-02	1.03E-05	2.53E-03	1.70E-03	3.57E-02	1.79E-02	1.03E-05	2.53E-03	2.97E-03	2.00E-01	1.81E-02	1.77E-05	2.53E-03	3.05E-03
Mercury (Hg)	2.46E-02	6.82E-04	7.25E-06	4.21E-04	1.82E-02	1.86E-02	6.51E-04	7.25E-06	4.21E-04	nd	3.02E-02	6.52E-04	7.16E-06	4.21E-04	nd
Molybdenum (Mo)	1.70E-06	3.05E-06	5.22E-10	9.09E-07	2.24E-07	1.71E-06	2.93E-06	5.22E-10	9.09E-07	2.85E-07	1.73E-06	2.93E-06	4.97E-10	9.09E-07	5.21E-07
Nickel (Ni)	4.36E-02	4.81E-05	1.10E-05	4.98E-03	3.93E-04	9.31E-02	6.18E-05	1.10E-05	4.98E-03	7.91E-03	1.18E-01	6.20E-05	1.70E-05	4.98E-03	7.98E-03
Selenium (Se)	3.11E-03	6.72E-03	6.62E-07	3.98E-03	1.24E-02	3.58E-03	6.84E-03	6.62E-07	3.98E-03	nd	3.75E-03	6.84E-03	6.90E-07	3.98E-03	nd
Silver (Ag)	1.24E-03	8.90E-03	3.97E-07	nd	7.39E-02	9.75E-04	8.61E-03	3.97E-07	nd	nd	9.75E-04	8.61E-03	3.71E-07	nd	nd
Vanadium (V)	4.16E-02	5.27E-05	1.32E-05	1.37E-03	3.87E-04	4.21E-02	5.28E-05	1.32E-05	1.37E-03	5.91E-03	1.29E-01	5.31E-05	1.71E-05	1.37E-03	5.91E-03
Zinc (Zn)	9.86E-05	2.25E-05	1.78E-08	8.20E-04	1.08E-04	9.84E-05	2.24E-05	1.78E-08	8.20E-04	1.67E-02	4.27E-04	2.34E-05	3.25E-08	8.20E-04	1.72E-02
Fluoride (F)	6.83E-03	4.13E-08	4.77E-07	nd	5.26E-02	3.87E-01	3.97E-07	4.77E-07	nd	nd	1.34E-01	1.60E-07	3.22E-06	nd	nd

Notes:
nd = not determined
Highlighted numbers denote country food with an exposure ratio 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

	Baseline		Operation		Closure	
Country Food	EDLE mg/kg/day	ILCR Unitless	EDLE mg/kg/day	ILCR Unitless	EDLE mg/kg/day	ILCR Unitless
Moose	5.99E-05	1.08E-04	2.59E-05	4.66E-05	2.73E-06	4.92E-06
Grouse	2.66E-04	4.79E-04	1.49E-04	2.69E-04	1.59E-05	2.86E-05
Snowshoe Hare	1.92E-08	3.45E-08	1.08E-08	1.94E-08	1.09E-09	1.97E-09
Berries	8.78E-07	1.58E-06	5.16E-07	9.29E-07	5.49E-08	9.88E-08
Dolly Varden	7.57E-06	1.36E-05	5.56E-06	3.33E-05	1.15E-05	6.90E-05

Notes:
Highlighted numbers indicate elevated incremental lifetime cancer risk.
EDLE = estimated daily lifetime exposure.
ILCR = incremental lifetime cancer risk.

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 Number of Servings[1]
Adult	Moose	Baseline	4.94	0.213	23.2	7.0
		Operation	6.29	0.213	29.5	7.0
		Closure	6.32	0.213	29.7	7.0
	Grouse	Baseline	0.04	0.299	0.1	0.1
		Operation	0.04	0.299	0.1	0.1
		Closure	0.04	0.299	0.1	0.1
	Hare	Baseline	217	0.348	624	0.1
		Operation	217	0.348	624	0.1
		Closure	233	0.348	671	0.1
	Berries	Baseline	5.08	0.28	18.1	0.2
		Operation	5.08	0.28	18.1	0.2
		Closure	5.08	0.28	18.1	0.2
	Dolly Varden	Baseline	0.47	0.28	1.7	0.1
		Operation	0.34	0.28	1.2	0.1
		Closure	0.34	0.28	1.2	0.1
Toddler	Moose	Baseline	1.15	0.091	12.6	7.0
		Operation	1.47	0.091	16.0	7.0
		Closure	1.48	0.091	16.1	7.0

(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 Number of Servings[1]
Toddler *(cont'd)*	Grouse	Baseline	0.01	0.13	0.1	0.1
		Operation	0.01	0.13	0.1	0.1
		Closure	0.01	0.13	0.1	0.1
	Hare	Baseline	50.67	0.15	339	0.1
		Operation	50.67	0.15	339	0.1
		Closure	54.50	0.15	364	0.1
	Berries	Baseline	1.19	0.12	9.8	0.2
		Operation	1.19	0.12	9.8	0.2
		Closure	1.84	0.12	15.3	0.2
	Dolly Varden	Baseline	0.11	0.12	0.9	0.1
		Operation	0.08	0.12	0.7	0.1
		Closure	0.08	0.12	0.7	0.1

Notes:
RMW = recommended maximum weekly
[1] based on annual averages from Jin (2006)

Under all three scenarios the RMWIs are greater than the current ingestion rate of moose reported by the country food harvesters. Thus, upon mine development and operation the country foods harvesters can continue to consume moose, snowshoe hare, grouse, berries, and Dolly Varden 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 scenario, 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 Appendix 25-A, 2009 Country Foods Baseline Report, 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 TMF were estimated using modelled water quality, which was based on the average of the source term data and assumed normal (base case) flows. This represents the most likely scenario. 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 metals in TMF sediments were assumed to be an average of metal concentrations measured in the rougher tailing samples from pilot plant trials and it was assumed that the rougher tailing were distributed equally in the TMF. It was further assumed that metals were 100% bio-available; therefore, this represents an overestimation of risks associated with uptake of metals from the TMF into plants and 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 sediment concentrations with BC and CCME (2010b) water quality guidelines for the protection of aquatic life, and sediment water quality for the protection of aquatic life (CCME 2002). These 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 (organic chemicals, etc.) may be associated with the Project operation, but did not occur under baseline conditions. Any such COPCs would be evaluated as part of future Project monitoring and mitigation measures.

Overall, there is high certainty that all metals that could be of potential concern during mine operation and closure were evaluated.

6.4 Food Chain Model

6.4.1 Vegetation

Metal concentrations in vegetation established on the TMF during closure were predicted using generic uptake (or biotransfer) factors that predict the concentration of metals in leaves via root uptake from the soil. The uptake factors were obtained from Staven et al. (2003) and the US EPA (2005) and do not take into account plant species-specific metal bioaccumulation rates. During closure, tailing that are not submerged will be capped with 0.5 m of till, and plants are unlikely to be able to establish roots in the tailing themselves. Thus, uncertainties in the plant tissue metal concentrations exist from unknown metal concentrations in soil and from unknown plant species-specific uptake factors and can lead to either over- or under-estimation of risks.

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 [BTFs] and 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 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 (i.e., chickens). Notwithstanding, this method is the accepted method to model the uptake of COPCs into animals when empirical data are not available or when samples sizes are too small to make conclusions about population tissue concentrations.

The moose, grouse, and snowshoe hare 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 TMF. For example, most soil ingestion by moose occurs incidentally from grazing on grasses or foraging for vegetation on the ground. In the TMF, there would be no vegetation during operation, and therefore there should be no incidental tailing ingestion. 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 still consume the tailing at the same ingestion rate associated with vegetation consumption from the TMF during closure. This would overestimate the EDI of all COPCs from the soil/sediment ingestion route.

The same approach was used for grouse because they may consume the coarse tailing material to aid in physically breaking down food in their gizzard and crops. Snowshoe hare are unlikely to spend considerable time in the TMF during operation because there is no food and cover available. However, during re-vegetation of the TMF during closure, snowshoe hare will increasingly use the TMF as habitat, which is reflected in the assumed increasing exposure times. Overall, it is anticipated that the soil and plant ingestion rates in the TMF 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 snowshoe hare would spend in the TMF was based on the home range of the animal relative to the TMF. This assumes that animals distribute the time they spend throughout their home range area equally. During operation, the TMF will provide no food for the animals, and poor habitat and protection from predators. Animals would likely seek more favourable areas outside of the TMF. In addition, human presence, mining infrastructure, and operations (noise, light) may be deterrents for moose, snowshoe hare, and grouse (Chapter 18, Wildlife and Wildlife Habitat, Sect ion 18.7.3). During closure, food and cover will eventually become available, disturbance will decrease over time, and animals may spend more time in the TMF. Overall, it is anticipated that the time spent by moose, snowshoe hare, and grouse in the TMF have been overestimated, which would subsequently result in conservatism in the risk estimates.

Other uncertainties associated with the predicted animal tissue concentrations during baseline 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.

The concentrations of metals that bioaccumulate in the aquatic food chain, i.e. selenium and mercury, were not modelled in fish because the uncertainties associated with metal concentrations in prey items are too large for a model to be considered at this time. Bioaccumulation factors are currently unknown for the assessed locations because the factors (especially for selenium) vary considerably with site-specific environmental condition. Monitoring of environmental media and fish tissue concentrations and conducting a detailed risk assessment should metal concentrations be shown to increase over time are recommended according to the Aquatics Effects Monitoring Plan (Chapter 26, Section 26.18.2).

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 Project area. This is an overestimate given the vast area available for harvesting and the distance from the communities to the Project area. 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 by (Jin 2006) for the Tahltan Nation. 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 (i.e., it is based on Tahltan Nation consumption from a wide range of areas within the Tahltan asserted territory and not only from the Project area). In addition, the data do not reflect the consumption of other country foods harvesters who may harvest from the Project area. 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 6 months to 4 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 in toddlers that consume moose tissue. 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 are 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 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, and hardness) 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 individual COPC levels and not for overall health effects.

6.6 Definition of Health

This country foods assessment is a science-based approach recommended by Health Canada (2004) 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.

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, operation, and closure of the KSM Project PTMA. The potential for residual human health effects caused by the consumption of five country foods (moose, snowshoe hare, grouse, berries, and Dolly Varden) 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, berries, and Dolly Varden during the baseline, operation, and closure scenarios. 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, 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

1.1 INTRODUCTION

A food chain model was used to predict metal concentrations in meat from moose, snowshoe hare, and grouse. 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 metal concentrations in the environmental media and species-specific characteristics (i.e., ingestion rates of each media and the time that an animal spends in and near the Processing and Tailing Management Area [PTMA]).

This section provides details on the methodology of the food chain model and the modeled metal concentrations in the tissue of the terrestrial country foods. The modelled metal 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 metal concentrations in moose, snowshoe hare, and grouse that spend their entire time in the existing environment (pre-Project) within and near the proposed PTMA.

2. Operation scenario — This scenario predicts the metal concentrations in moose, snowshoe hare, and grouse when the KSM Project (the Project) is operational. The scenario assumes that moose, snowshoe hare, and grouse would spend most of their time in or near the PTMA with a small proportion of time spent in the Tailing Management Facility (TMF). Metals concentrations in environmental media (i.e., water and soil) in the TMF under the operation scenario were modelled. Modelled water concentrations reflected the water that moose, snowshoe hare, and grouse would drink when they enter the TMF. Modelled soil concentrations reflect the soil that moose, snowshoe hare, and grouse would eat when they enter the TMF. Incidental soil ingestion by wildlife, particularly herbivores, is well documented. These modelled concentrations were used to predict changes in the concentrations of animal tissue during Project operation.

3. Closure scenario — This scenario predicts the metal 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 most of their time in or near the PTMA with a small proportion of time spent in the TMF. The TMF will undergo re-vegetation for wildlife habitat (Chapter 27, Closure and Reclamation) and it is assumed that this vegetation will be exposed to metals in the tailings to a minor extent and will be accessible to wildlife. It is also assumed that the CIL Plant has been made inaccessible to wildlife by fencing or other means should water quality exceed guidelines (Chapter 26.21, Wildlife Management Plan). Metals concentrations in environmental media (i.e., water, vegetation, and soil) in the TMF under the closure scenario were modelled. Modelled water and soil concentrations reflected the water and tailings that moose, snowshoe hare, and grouse would ingest when they enter the TMF. Modelled vegetation concentrations reflect the above-ground vegetation that moose, snowshoe hare, and grouse would eat when they enter the TMF. Incidental soil ingestion by wildlife, particularly herbivores, is well documented. These modelled concentrations were used to predict changes in the concentrations of animal tissue during Project operation.

The following sections provide the food chain model methods and predicted concentrations for moose and grouse for the scenarios described above.

1.2 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 metal in moose, snowshoe hare, or grouse from consuming soil, vegetation, and water
C_{msoil} = Concentration of metal in meat from the animals' exposure to metals in soil.
C_{mveg} = Concentration of metal in meat from the animals' exposure to metals in vegetation.
C_{mwater} = Concentration of metal 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 A-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	$C_{spp\text{-}water} = BTF_{tissue\text{-}food}\ (day/kg) \times C_{water}\ (mg/L) \times IR_{water}\ (L/day) \times ET$

Notes:
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 and TMF
ET = exposure time spent in and near the PTMA, including the TSF (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 metal.
2. Metal Concentrations in Environmental Media.
3. Wildlife exposure characteristics: ingestion rate (IR) and exposure time (ET).

1.2.1 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 biotransfer factor (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 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. Metal-specific plant bioconcentration factors were obtained and represent uptake of contaminants of potential concern by the root from the soil and transport to the aboveground plant tissue (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		BTF plant	
COPC (Total)	**day/kg**	**Reference**	**day/kg**	**Reference**	**Unitless**	**Reference**
Aluminum	0.0015	1	0.8	3	0.0004	2
Arsenic	0.002		0.83	2	0.008	4
Barium	0.00015		0.009	2	0.015	4
Beryllium	0.001		0.4	2	0.0015	4
Cadmium	0.00012		0.10625		0.064	4
Chromium	0.0055		0.2	2	0.0045	4
Cobalt	0.01	2	2	2	0.007	2
Copper	0.009	1	0.5	2	0.25	2
Mercury	0.01	1	0.03	2	0.37	2
Molybdenum	0.001	2	0.18	2	0.05	2
Nickel	0.006		0.001	2	0.008	4
Selenium	0.002265		1.12625		0.022	4
Silver	0.003		2	2	0.1	4
Vanadium	0.0025	1	0.0003		0.1	2
Zinc	0.00009		0.00875		0.9	4
Fluoride	0.15	2	0.014	2	0.006	2

1.2.2 Metal Concentrations in Environmental Media

Metal concentrations in environmental media were assessed for three scenarios: baseline, operation, and closure. Metal 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). Metal concentrations in the soil/sediment and water within the TMF during Project operation and closure were modelled (Appendix 14-J). 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 using an equation from *Calculating Upper Confidence Limits for Exposure Point Calculations at Hazardous Waste Sites* (US EPA 2002). The TMF conditions were modelled as the average of the rougher tailing metals concentrations in sediment and the maximum of the monthly average concentrations in base flow conditions that would be present during operation and closure as the a conservative estimate. The operation scenario assumes that there will be no vegetation in the TMF, as it is predicted that the TMF is still active and has poor fertility. Thus, all of the vegetation that animals consume will be outside of the TMF and represented using baseline vegetation metals concentrations. During closure, the tailing will be capped and re-vegetated to provide wildlife habitat. It is therefore assumed that wildlife that enters the TMF will have access to vegetation that is in contact with the tailing through their roots. This represents a conservative estimate as capping provides rooting material free of contaminants of potential concern. 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. Metal Concentrations in Surface Water, Soil, and Plant Tissue

	Measured Baseline (95% UCLM)			Modelled TMF COPC Concentrations			
COPC (Total)	Vegetation mg/kg ww $C_{base\text{-}veg}$	Soil mg/kg dw $C_{base\text{-}soil}$	Water mg/L $C_{base\text{-}water}$	Vegetation mg/kg ww $C_{TMF\text{-}veg}$	Maximum Soil mg/kg dw $C_{TMF\text{-}soil}$	Average Water-Op mg/L $C_{TMF\text{-}water}$	Average Water-Clo mg/L $C_{TMF\text{-}water}$
Aluminum	31.3	30081.5	0.3	7.1	70978.8	0.483	0.177
Arsenic	0.0089	65.9	0.0002	0.012	5.9	0.0320	0.0114
Barium	8.7	400.9	0.0224	9.2	2443.0	0.269	0.0965
Beryllium	0.033	2.0	0.0002	0.0004	0.9	0.000522	0.000275
Cadmium	0.050	0.792	1.54E-05	0.0051	0.3	0.0000835	0.0000412
Chromium	0.151	111.3	0.0013	0.034	30.4	0.00353	0.00130
Cobalt	0.117	42.0	0.0003	0.025	14.2	0.0060	0.0030
Copper	1.003	360.1	0.0012	23.9	382.2	0.0255	0.0141
Mercury	0.0020	0.758	6.91E-06	0.0055	0.1	0.000171	0.000059
Molybdenum	0.055	43.4	0.0004	0.101	8.1	0.219	0.0888
Nickel	0.577	58.3	0.0017	0.8	395.8	0.00480	0.00209
Selenium	0.093	4.0	0.0008	0.030	5.4	0.0210	0.0210
Silver	nd	2.5	9.12E-06	0.021	0.8	0.000040	0.000040
Vanadium	0.057	176.4	0.0011	4.5	180.3	0.0177	0.0062
Zinc	7.7	128.2	0.0027	27.0	119.9	0.0258	0.0110
Fluoride	nd	nd	0.035	nd	nd	5.99	2.02

1.2.3 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 (i.e., the area near the PTMA versus the TMF) 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 metal concentrations in moose, snowshoe hare, and grouse. The parameters included the IR of each media (IR_{veg}, IR_{soil}, and IR_{water}) and the ET or fraction of the year spent in either the general area, or within the TMF during operation (ET_{base}, ET_{TMF}). 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 scenario is 1, as these animals could spend 100% of their time in and near the proposed PTMA.

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 in Baseline Area		Et_{base}	1	1	1
Exposure Time in TMF Area		ET_{TMF}	0	0	0
Operations Scenario					
Exposure Time in Baseline Area		Et_{base}	0.68	0.95	1
Exposure Time in TMF Area		ET_{TMF}	0.32	0.05	0
Closure Scenario					
Exposure Time in Baseline Area		Et_{base}	0.68	0.95	0.9
Exposure Time in TMF Area		ET_{TMF}	0.32	0.05	0.1

For the operation and closure scenarios, the time that the animals would spend in the TMF and the time that they would spend in the rest of the assessment area was calculated based on two factors. These factors included the home range of the animal and number of weeks per year that the animal actively forages and could be exposed to the environmental media concentrations. For the TMF, the exposure time was calculated as follows:

$$Exposure\ Time\ (unitless) = \frac{Active\ Weeks}{Weeks\ per\ year\ (52)} + \frac{TMF\ Area\ (1{,}363.29\ ha)}{Home\ range\ of\ animal}$$

For moose, a non-migratory home range of 4,220 ha was assumed(Demarchi 2003). In addition, moose were assumed to be active in the area for the entire year (52 weeks) because during winter months they may attempt to forage for grass and lichens beneath the snow. A conservative assumption was made that the moose would use its entire home range equally and since the TMF is 32.3% of a moose's home range, it was assumed that this would be the amount of time it would spend in the TMF. 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. For moose, during operation the ET_{TMF} was 0.323 and the ET_{base} was 0.677.

For grouse, the home range area is less than the TMF (PTMA; 40 ha; Ellison 1971). Thus, the entire home range could be within the TMF and the ratio of TMF to home range would be 1.0. Grouse could be active for half of the year (26 weeks) in the TMF because the area will be frozen and covered with snow during the winter. During this time, the water, and tailing will be unavailable for consumption. It would not be possible for the grouse to survive by living its entire active period in the TMF because there would be no food available. A conservative estimate of the time spent in the TMF is 10% of the day (2.4 hours) during the active weeks. The resulting ET_{TMF} for grouse was 0.05 in the TMF and 0.95 for the time spent in the baseline area (ET_{base}). 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.

The home range area for snowshoe hare is also less than the TMF (4 ha; US EPA 1993). Thus, the entire home range could be within the TMF and the ratio of the TMF to home range would be 1.0. It can be assumed that snowshoe hare will not be active in the TMF during operation because of the lack of edible vegetation and cover. During closure, snowshoe hare may feed on the vegetation in the TMF for half of the year (26 weeks) because the area will be frozen and covered with snow during the winter. During this time, the vegetation, water, and tailing will be unavailable for consumption. It would not be possible for the snowshoe hare to survive by living its entire active period in the TMF during closure because there would be less food and cover available than in surrounding forest habitats. A conservative estimate of the time spent in the TMF is 20% of the day (4.8 hours) during the active weeks. The resulting ET_{TMF} for snowshoe hare was 0.1 in the TMF and 0.9 for the time spent in the baseline area (ET_{base}). 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.

When considering ET for vegetation consumption, all of the vegetation consumed by moose, snowshoe hare, and grouse would be from outside the TMF because during operation there would be no vegetation growing in the TMF. During closure, the TMF will be re-vegetated and vegetation will become available for wildlife consumption. ETs were calculated as described above.

1.3 FOOD CHAIN MODEL SAMPLE CALCULATION

To calculate the amount of metal 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 x C x IR x 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	$C_{spp\text{-}soil} = (BTF_{spp\text{-}metal} \times C_{base\text{-}soil} \times IR_{soil} \times ET_{base}) + (BTF_{spp\text{-}metal} \times C_{TMF\text{-}soil} \times IR_{soil} \times ET_{TMF})$
Vegetation Ingestion	$C_{spp\text{-}veg} = BTF_{spp\text{-}metal} \times C_{base\text{-}veg} \times IR_{veg} \times ET_{base}$
Water Ingestion	$C_{spp\text{-}water} = (BTF_{spp\text{-}metal} \times C_{base\text{-}water} \times IR_{water} \times ET_{base}) + (BTF_{spp\text{-}metal} \times C_{TMF\text{-}water} \times IR_{water} \times ET_{TMF})$
Closure Ingestion Equations	
Soil Ingestion	$C_{spp\text{-}soil} = (BTF_{spp\text{-}metal} \times C_{base\text{-}soil} \times IR_{soil} \times ET_{base}) + (BTF_{spp\text{-}metal} \times C_{TMF\text{-}soil} \times IR_{soil} \times ET_{TMF})$
Vegetation Ingestion	$C_{spp\text{-}veg} = (BTF_{spp\text{-}metal} \times C_{base\text{-}veg} \times IR_{veg} \times Etbase)+(BTF_{spp\text{-}metal} \times C_{TMF\text{-}veg} \times IRveg \times ET_{TMF})$
Water Ingestion	$C_{spp\text{-}water} = (BTF_{spp\text{-}metal} \times C_{base\text{-}water} \times IR_{water} \times ET_{base}) + (BTF_{spp\text{-}metal} \times C_{TMF\text{-}water} \times IR_{water} \times ET_{TMF})$

Notes:
$C_{spp\text{-}media}$ = 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	
$\mathbf{C_{meat} = C_{ssp\text{-}veg} + C_{ssp\text{-}soil} + C_{ssp\text{-}water}}$	
where:	
$C_{spp\text{-}veg} = BTF_{spp\text{-}metal} \times C_{base\text{-}veg} \times IR_{veg} \times ET_{base}$	
$C_{spp\text{-}soil} = BTF_{spp\text{-}metal} \times C_{base\text{-}soil} \text{ x } IR_{soil} \times ET_{base}$	
$C_{spp\text{-}water} = BTF_{spp\text{-}metal} \times C_{base\text{-}water} \times IR_{water} \times ET_{base}$	
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) × (23.14 mg/kg ww) × (9.8 kg/day) × 1
	= 0.340 mg/kg
$C_{spp\text{-}soil}$	= (0.0015 day/kg) × (30,081 mg/kg dw) × (0.15 kg/day) × 1
	= 6.77 mg/kg
$C_{spp\text{-}water}$	= (0.0015mg/kg) × (0.316 mg/L) × 25 L/day) × 1
	= 0.0118 mg/kg
C_{meat}	= (0.340 + 6.77 + 0.0118) mg/kg
	= 7.122 mg/kg

1.4 FOOD CHAIN MODEL RESULTS

Tables A-7, A-8, and A-9 present the modelled moose, snowshoe hare, and grouse concentrations for 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 ($C_{base\text{-}moose}$, $C_{base\text{-}grouse}$, $C_{TMF\text{-}moose}$ and $C_{TMF\text{-}grouse}$). These metal 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 from the PTMA would be exposed to.

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

.	$C_{moose-veg}$	$C_{moose-soil}$	$C_{moose-water}$	$C_{base-moose}$	$C_{grouse-veg}$	$C_{grouse-soil}$	$C_{grouse-water}$	$C_{base-grouse}$	$C_{hare-veg}$	$C_{hare-soil}$	$C_{hare-water}$	$C_{base-hare}$
Aluminum (Al)-Total	4.60E-01	6.77E+00	1.18E-02	**7.24E+00**	2.10E+00	1.68E+03	1.77E-02	**1.69E+03**	4.95E-03	1.62E-01	6.14E-05	**1.67E-01**
Arsenic (As)-Total	1.74E-04	1.98E-02	8.75E-06	**1.99E-02**	6.20E-04	3.83E+00	1.02E-05	**3.83E+00**	1.87E-06	4.72E-04	4.54E-08	**4.74E-04**
Barium (Ba)-Total	1.28E-02	9.02E-03	8.42E-05	**2.19E-02**	6.57E-03	2.53E-01	1.41E-05	**2.59E-01**	1.37E-04	2.15E-04	4.37E-07	**3.53E-04**
Beryllium (Be)-Total	3.27E-04	2.94E-04	5.37E-06	**6.27E-04**	1.12E-03	5.49E-02	6.01E-06	**5.60E-02**	3.52E-06	7.02E-06	2.79E-08	**1.06E-05**
Cadmium (Cd)-Total	5.86E-05	1.43E-05	4.61E-08	**7.29E-05**	4.45E-04	5.89E-03	1.14E-07	**6.34E-03**	6.30E-07	3.40E-07	2.39E-10	**9.70E-07**
Chromium (Cr)-Total	8.12E-03	9.18E-02	1.79E-04	**1.00E-01**	2.53E-03	1.56E+00	1.82E-05	**1.56E+00**	8.72E-05	2.19E-03	9.29E-07	**2.28E-03**
Cobalt (Co)-Total	1.15E-02	6.30E-02	6.75E-05	**7.46E-02**	1.97E-02	5.88E+00	3.78E-05	**5.90E+00**	1.24E-04	1.50E-03	3.50E-07	**1.63E-03**
Copper (Cu)-Total	8.85E-02	4.86E-01	2.67E-04	**5.75E-01**	4.21E-02	1.26E+01	4.15E-05	**1.26E+01**	9.50E-04	1.16E-02	1.38E-06	**1.26E-02**
Mercury (Hg)-Total	1.92E-04	1.14E-03	1.73E-06	**1.33E-03**	4.94E-06	1.59E-03	1.45E-08	**1.60E-03**	2.06E-06	2.71E-05	8.97E-09	**2.92E-05**
Molybdenum (Mo)-Total	5.36E-04	6.51E-03	1.05E-05	**7.06E-03**	8.27E-04	5.47E-01	5.28E-06	**5.48E-01**	5.76E-06	1.55E-04	5.44E-08	**1.61E-04**
Nickel (Ni)-Total	3.39E-02	5.24E-02	2.55E-04	**8.66E-02**	4.85E-05	4.08E-03	1.19E-07	**4.13E-03**	3.65E-04	1.25E-03	1.33E-06	**1.62E-03**
Selenium (Se)-Total	2.07E-03	1.36E-03	4.39E-05	**3.48E-03**	8.83E-03	3.16E-01	6.11E-05	**3.25E-01**	2.23E-05	3.25E-05	2.28E-07	**5.50E-05**
Silver (Ag)-Total	nc	1.12E-03	6.84E-07	**1.12E-03**	nc	3.47E-01	1.28E-06	**3.47E-01**	nc	2.66E-05	3.55E-09	**2.67E-05**
Vanadium (V)-Total	1.39E-03	6.61E-02	7.10E-05	**6.76E-02**	1.43E-06	3.70E-03	2.39E-08	**3.71E-03**	1.49E-05	1.58E-03	3.68E-07	**1.59E-03**
Zinc (Zn)-Total	6.81E-03	1.73E-03	6.10E-06	**8.55E-03**	5.68E-03	7.85E-02	1.66E-06	**8.42E-02**	7.32E-05	4.13E-05	3.17E-08	**1.15E-04**
Fluoride (F)	nc	nc	1.29E-01	**1.29E-01**	nc	nc	3.38E-05	**3.38E-05**	nc	nc	6.72E-04	**6.72E-04**

Notes:
nc = not calculated due to lack of environmental media data
Bolded numbers indicate concentration of COPC in meat

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

COPC	$C_{moose-veg}$	$C_{moose-soil}$	$C_{moose-water}$	$C_{base-moose}$	$C_{grouse-veg}$	$C_{grouse-soil}$	$C_{grouse-water}$	$C_{base-grouse}$	$C_{hare-veg}$	$C_{hare-soil}$	$C_{hare-water}$	$C_{base-hare}$
Aluminum (Al)-Total	4.60E-01	9.74E+00	1.39E-02	**1.02E+01**	2.10E+00	1.80E+03	1.82E-02	**1.80E+03**	4.95E-03	1.62E-01	6.14E-05	**1.67E-01**
Arsenic (As)-Total	1.74E-04	1.40E-02	5.23E-04	**1.47E-02**	6.20E-04	3.65E+00	1.03E-04	**3.65E+00**	1.87E-06	4.72E-04	4.54E-08	**4.74E-04**
Barium (Ba)-Total	1.28E-02	2.39E-02	3.83E-04	**3.70E-02**	6.57E-03	3.17E-01	2.19E-05	**3.23E-01**	1.37E-04	2.15E-04	4.37E-07	**3.53E-04**
Beryllium (Be)-Total	3.27E-04	2.45E-04	7.85E-06	**5.80E-04**	1.12E-03	5.35E-02	6.44E-06	**5.46E-02**	3.52E-06	7.02E-06	2.79E-08	**1.06E-05**
Cadmium (Cd)-Total	5.86E-05	1.15E-05	1.12E-07	**7.02E-05**	4.45E-04	5.72E-03	1.40E-07	**6.16E-03**	6.30E-07	3.40E-07	2.39E-10	**9.70E-07**
Chromium (Cr)-Total	8.12E-03	7.02E-02	2.78E-04	**7.86E-02**	2.53E-03	1.50E+00	1.98E-05	**1.50E+00**	8.72E-05	2.19E-03	9.29E-07	**2.28E-03**
Cobalt (Co)-Total	1.15E-02	4.95E-02	5.30E-04	**6.16E-02**	1.97E-02	5.68E+00	7.79E-05	**5.70E+00**	1.24E-04	1.50E-03	3.50E-07	**1.63E-03**
Copper (Cu)-Total	8.85E-02	4.96E-01	2.03E-03	**5.86E-01**	4.21E-02	1.26E+01	8.39E-05	**1.27E+01**	9.50E-04	1.16E-02	1.38E-06	**1.26E-02**
Mercury (Hg)-Total	1.92E-04	7.99E-04	1.50E-05	**1.01E-03**	4.94E-06	1.52E-03	3.17E-08	**1.52E-03**	2.06E-06	2.71E-05	8.97E-09	**2.92E-05**
Molybdenum (Mo)-Total	5.36E-04	4.80E-03	1.78E-03	**7.11E-03**	8.27E-04	5.25E-01	1.43E-04	**5.26E-01**	5.76E-06	1.55E-04	5.44E-08	**1.61E-04**
Nickel (Ni)-Total	3.39E-02	1.51E-01	4.05E-04	**1.85E-01**	4.85E-05	5.26E-03	1.30E-07	**5.31E-03**	3.65E-04	1.25E-03	1.33E-06	**1.62E-03**
Selenium (Se)-Total	2.07E-03	1.52E-03	4.15E-04	**4.01E-03**	8.83E-03	3.22E-01	1.41E-04	**3.31E-01**	2.23E-05	3.25E-05	2.28E-07	**5.50E-05**
Silver (Ag)-Total	nc	8.79E-04	1.43E-06	**8.80E-04**	nc	3.36E-01	1.49E-06	**3.36E-01**	nc	2.66E-05	3.55E-09	**2.67E-05**
Vanadium (V)-Total	1.39E-03	6.66E-02	4.06E-04	**6.84E-02**	1.43E-06	3.71E-03	4.12E-08	**3.71E-03**	1.49E-05	1.58E-03	3.68E-07	**1.59E-03**
Zinc (Zn)-Total	6.81E-03	1.69E-03	2.29E-05	**8.53E-03**	5.68E-03	7.83E-02	2.37E-06	**8.39E-02**	7.32E-05	4.13E-05	3.17E-08	**1.15E-04**
Fluoride (F)	nc	nc	7.34E+00	**7.34E+00**	nc	nc	3.26E-04	**3.26E-04**	nc	nc	6.72E-04	**6.72E-04**

Notes:
nc = not calculated due to lack of environmental media data
Bolded numbers indicate concentration of COPC in meat

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

COPC	$C_{moose-veg}$	$C_{moose-soil}$	$C_{moose-water}$	$C_{base-moose}$	$C_{grouse-veg}$	$C_{grouse-soil}$	$C_{grouse-water}$	$C_{base-grouse}$	$C_{hare-veg}$	$C_{hare-soil}$	$C_{hare-water}$	$C_{base-hare}$
Aluminum (Al)-Total	4.46E-01	9.74E+00	1.02E-02	**1.02E+01**	2.09E+00	1.80E+03	1.73E-02	**1.80E+03**	4.90E-03	1.83E-01	5.87E-05	**1.88E-01**
Arsenic (As)-Total	4.19E-04	1.40E-02	1.89E-04	**1.46E-02**	7.55E-04	3.65E+00	4.27E-05	**3.65E+00**	2.69E-06	4.29E-04	3.36E-07	**4.32E-04**
Barium (Ba)-Total	2.60E-02	2.39E-02	1.74E-04	**5.01E-02**	7.62E-03	3.17E-01	1.65E-05	**3.25E-01**	1.81E-04	3.25E-04	5.81E-07	**5.07E-04**
Beryllium (Be)-Total	2.26E-04	2.45E-04	5.85E-06	**4.77E-04**	1.07E-03	5.35E-02	6.10E-06	**5.46E-02**	3.18E-06	6.66E-06	2.86E-08	**9.87E-06**
Cadmium (Cd)-Total	4.74E-05	1.15E-05	7.11E-08	**5.90E-05**	4.32E-04	5.72E-03	1.24E-07	**6.15E-03**	5.93E-07	3.20E-07	2.79E-10	**9.13E-07**
Chromium (Cr)-Total	7.88E-03	7.02E-02	1.79E-04	**7.83E-02**	2.52E-03	1.50E+00	1.82E-05	**1.50E+00**	8.64E-05	2.03E-03	9.28E-07	**2.12E-03**
Cobalt (Co)-Total	1.09E-02	4.95E-02	2.92E-04	**6.08E-02**	1.96E-02	5.68E+00	5.72E-05	**5.70E+00**	1.22E-04	1.40E-03	7.10E-07	**1.53E-03**
Copper (Cu)-Total	2.78E+00	4.96E-01	1.20E-03	**3.28E+00**	2.41E-01	1.26E+01	6.40E-05	**1.29E+01**	9.91E-03	1.17E-02	2.89E-06	**2.16E-02**
Mercury (Hg)-Total	8.31E-04	7.99E-04	5.96E-06	**1.64E-03**	7.48E-06	1.52E-03	2.00E-08	**1.53E-03**	4.19E-06	2.46E-05	1.58E-08	**2.88E-05**
Molybdenum (Mo)-Total	1.65E-03	4.80E-03	7.24E-04	**7.17E-03**	1.09E-03	5.25E-01	6.09E-05	**5.26E-01**	9.45E-06	1.43E-04	1.20E-06	**1.53E-04**
Nickel (Ni)-Total	8.31E-02	1.51E-01	2.74E-04	**2.34E-01**	5.94E-05	5.26E-03	1.21E-07	**5.32E-03**	5.28E-04	1.98E-03	1.36E-06	**2.51E-03**
Selenium (Se)-Total	2.26E-03	1.52E-03	4.15E-04	**4.20E-03**	8.96E-03	3.22E-01	1.41E-04	**3.31E-01**	2.29E-05	3.37E-05	8.23E-07	**5.74E-05**
Silver (Ag)-Total	nc	8.79E-04	1.43E-06	**8.80E-04**	nc	3.36E-01	1.49E-06	**3.36E-01**	nc	2.49E-05	4.75E-09	**2.49E-05**
Vanadium (V)-Total	1.44E-01	6.66E-02	1.74E-04	**2.10E-01**	2.41E-05	3.71E-03	2.92E-08	**3.73E-03**	4.88E-04	1.58E-03	5.33E-07	**2.07E-03**
Zinc (Zn)-Total	3.54E-02	1.69E-03	1.21E-05	**3.71E-02**	9.36E-03	7.83E-02	1.91E-06	**8.76E-02**	1.68E-04	4.10E-05	4.13E-08	**2.09E-04**
Fluoride (F)	nc	nc	2.53E+00	**2.53E+00**	nc	nc	1.31E-04	**1.31E-04**	nc	nc	4.53E-03	**4.53E-03**

Notes:
nc = not calculated due to lack of environmental media data
Bolded numbers indicate concentration of COPC in meat

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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

$$EDI_{meat} = \frac{IR \times Fs \times C\ meat}{BW}$$

$$EDI_{meat} = \frac{0.0916\ kg/day \times 0.997 \times 7.11\ mg/kg}{16.5\ kg}$$

$$EDI_{meat} = 0.0394\ mg/kg\ bw/day$$

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} =	7.24
BW =	16.5
EDI =	0.0401

APPENDIX C – SAMPLE CALCULATION OF ESTIMATED DAILY LIFETIME EXPOSURE OF ARSENIC FOR AN ADULT CONSUMING DOLLY VARDENTISSUE (OPERATIONS)

Appendix C. Sample Calculation of Estimated Daily Lifetime Exposure of Arsenic for an Adult Consuming Dolly VardenTissue (Operations)

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

$ELDE_{country\ food}$ =	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	0.279 kg/day
$C_{countryfood}$	0.100 mg/kg ww
Fs	0.0192
YE = LE	70
BW	70.7 kg

$$ELDE_{country\ food} = \frac{0.279\ kg/day \times 0.0192 \times 0.01\ mg/kg\ ww \times 70\ yr}{70.7\ kg\ bw \times 70\ yr}$$

$ELDE_{country\ food}$ = 7.57×10^{-6} 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:

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

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.

$$RMWI = \frac{1.0\ mg/kg/d \times 16.5kg \times 7d/week}{7.11\ mg/kg}$$

$$= 16.2\ kg\ moose/week$$

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 were based on predicted cobalt concentrations, while for grouse on predicted aluminum, for berries on measured thallium, and for Dolly Varden on measured silver concentrations.

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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

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

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

	Baseline RMWI					Operations RMWI					Closure RMWI				
COPC	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden
Aluminum	68	0.29	2972	37	5	48	0.27	2972	37	4	49	0.27	2626	37	4
Arsenic	7	0.04	313	22	1	10	0.04	313	22	0	10	0.04	344	22	0
Barium	4526	382	280492	40	45	2674	306	280492	40	56	1976	305	195286	40	53
Beryllium	1579	18	93671	23	20	1706	18	93671	23	15	2076	18	100325	23	14
Cadmium	6787	78	510006	123	4	7047	80	510006	123	9	8387	80	542136	123	9
Chromium	5	0	217	5	0	6	0	217	5	0	6	0	234	5	0
Cobalt	7	0.08	304	29	2	8	0.09	304	29	1	8	0.09	324	29	1
Copper	121	6	5559	73	63	119	6	5559	73	36	21	5	3233	73	35
Mercury	112	93	5083	282	8	148	97	5083	282	-	91	97	5148	282	-
Molybdenum	1963900	25304	85977591	159029	374519	1947915	26368	85977591	159029	294763	1932888	26359	90348390	159029	161409
Nickel	63	1319	3366	24	176	29	1026	3366	24	9	23	1024	2172	24	9
Selenium	811	9	51253	27	5	704	9	51253	27	-	672	9	49131	27	-
Silver	2215	7	92842	-	1	2811	7	92842	-	-	2811	7	99383	-	-
Vanadium	66	1202	2794	87	178	65	1201	2794	87	5	21	1193	2151	87	5
Zinc	32993	3350	2462788	172	762	33069	3360	2462788	172	-	7612	3219	1348383	172	-
Fluoride	401	1535546	77350	-	1	7	159567	77350	-	12	21	396522	11468	-	12
Lowest RMWI	**5**	**0.04**	**217**	**5**	**0.5**	**6**	**0.04**	**217**	**5**	5	**6**	**0.04**	**234**	**5**	5

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

	Baseline RMWI					Operations RMWI					Closure RMWI				
COPC	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden	Moose	Grouse	Hare	Berries	Dolly Varden
Aluminum	16	0.07	694	9	1	11	0.06	694	9	1	11	0.06	613	9	1
Arsenic	2	0.01	73	5	0.35	2	0.01	73	5	0	2	0.01	80	5	0
Barium	1056	89	65461	9	10	624	71	65461	9	13	461	71	45576	9	12
Beryllium	368	4	21861	5	5	398	4	21861	5	3	484	4	23414	5	3
Cadmium	1584	18	119025	29	1	1645	19	119025	29	2	1957	19	126524	29	2
Chromium	1	0	51	1	0	1	0	51	1	0	1	0	55	1	0.1
Cobalt	2	0.02	71	7	0.45	2	0.02	71	7	0	2	0.02	76	7	0.3
Copper	18	1	837	11	9	18	1	837	11	5	3	1	487	11	5
Mercury	26	22	1186	66	1	34	23	1186	66	-	21	23	1201	66	-
Molybdenum	376490	4851	16482368	30487	71797	373426	5055	16482368	30487	56508	370545	5053	17320274	30487	30943
Nickel	15	308	786	6	41	7	239	786	6	2	5	239	507	6	2
Selenium	206	2	13011	7	1	179	2	13011	7	-	171	2	12472	7	-
Silver	517	2	21668	-	0.22	656	2	21668	-	-	656	2	23194	-	-
Vanadium	15	281	652	20	42	15	280	652	20	1	5	279	502	20	1
Zinc	6484	658	484014	34	150	6499	660	484014	34	-	1496	633	264999	34	-
Fluoride	94	358366	18052	-	0.31	2	37240	18052	-	3	5	92541	2676	-	3
Lowest RMWI	**1**	**0.01**	**51**	**1**	**0.11**	**1**	**0.01**	**51**	**1**	**1**	**1**	**0.01**	**55**	**1**	**0.2**