Appendix 21-A

Brucejack Gold Mine Project: Country Foods Baseline Assessment

ERM

Pretium Resources Inc.

BRUCEJACK GOLD MINE PROJECT
Country Foods Baseline Assessment

PRETIVM

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BRUCEJACK GOLD MINE PROJECT
COUNTRY FOODS BASELINE ASSESSMENT

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PRETIVM

Pretium Resources Inc.

Prepared by:

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Executive Summary

Engineers and Scientists

Executive Summary

The Brucejack Gold Mine Project (the Project) is located at 56°28'20" N latitude by 130°11'31" W longitude, which is approximately 950 km northwest of Vancouver, 65 km north-northwest of Stewart, 21 km south-southeast of the closed Eskay Creek Mine, and approximately 40 km upstream from the border of British Columbia and Alaska. The Project is located on provincial Crown land within the Regional District of Kitimat-Stikine.

People in the region harvest country foods as part of their diet. The quality of country foods is directly related to the quality of the surrounding environmental media (e.g., soil, water, and vegetation). The proposed development of the Project has the potential to impact environmental media, thus assessment of county foods quality is necessary. This assessment provides the concentrations of contaminants of potential concern (COPCs) in country foods and the estimated consumption rates of each food by the harvesters under baseline conditions (i.e., prior to Project construction). The main objective of this country foods baseline assessment is to characterize baseline health risk posed by consumption of country foods within a defined country foods study area for the Project.

The country foods baseline assessment integrated the results of environmental media baseline studies, human receptor characteristics, and regulatory-based toxicity reference values (TRVs). The quality of five country foods was estimated using baseline levels of metals prior to development of the Project. This study evaluated potential health risks associated with the ingestion of naturally-occurring metals concentrations in the country foods.

Animal and plant species were selected for evaluation based on current harvesting and consumption patterns by local people. The Project is located in a relatively remote location, distant from the population centres of Stewart, Smithers, and Terrace. Thus the primary consumer group of country foods was identified as local First Nations. In total, five different country food groups were evaluated, including: large terrestrial mammals (moose, *Alces alces*), small terrestrial mammals (snowshoe hare, *Lepus americanus*), birds (grouse, *Phasianidae* sp.), fish (Dolly Varden ,*Salvelinus malma malma*/bull trout, *S. confluentus*), and berries (huckleberry, *Vaccinium membanaceum*; Bog blueberry, *Vaccinium uliginosum*; Alaskan blueberry, *V. ovalifolium*; and Canada buffaloberry, *Sheperdia canadensis*).

This assessment predicted no unacceptable health risks to people from consuming moose, snowshoe hare, grouse, berries, and Dolly Varden/bull trout under the existing pre-Project conditions. This means that consumption of these country foods at the quantities and frequencies used in the assessment would be considered safe and would not affect human health.

The estimates of risk due to consumption of country foods from within the study area outlined in this assessment are expected to be over-estimated as conservative assumptions for environmental data and human receptor characteristics were used in the assessment. Conservative assumptions included: the use 95% upper confidence limit of the mean (UCLM) of metal concentration to estimate the tissue metal concentrations for all country foods and in the calculation of recommended maximum weekly intakes (RMWIs) and ILCRs, the duration for which country food animals were assumed to be present within the study area, the consumption frequencies of country foods, and the portion size of country foods consumed.

Acknowledgements

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This report was produced for Pretium Resources Inc. (Pretivm) by Rescan Environmental Services Ltd. It was written by Golnar Zandpour (M.E.T) and edited by Lesley Shelley (Ph.D.) and Michael Henry (Ph.D.). Greg Norton (M.Sc.) was the project manager and Nicole Bishop (B.Sc.) the project coordinator. Graphics production was coordinated by Francine Alford (B.F.A.), GIS production was coordinated by Pieter van Leuzen (M.Sc.) and report production was coordinated by Robert Tarbuck (BTECH).

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BRUCEJACK GOLD MINE PROJECT
COUNTRY FOODS BASELINE ASSESSMENT

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Acronyms and Abbreviations

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Acronyms and Abbreviations

ALS	ALS Environmental
BTF	biotransfer factor
BW	body weight
CCME	Canadian Council of Ministers of the Environment
CHHAD	Chemical Health Hazard Assessment Division
COPC	contaminant of potential concern
EDI	estimated daily intake
ELDE	estimated lifetime daily exposure
ER	exposure ratio
FAO	Food and Agriculture Organization of the United Nations
ILCR	incremental lifetime cancer risk
INAC	Indian and Northern Affairs Canada
IQ	intelligence quotient
IR	ingestion rate
IRIS	Integrated Risk Information System
JECFA	Joint FAO/WHO Expert Committee on Food Additives
LOAEL	lowest observed adverse effect level
MDL	method detection limit
NCP	Northern Contaminants Program
NOAEL	no observed adverse effect level
POPs	persistent organic pollutants
PTDI	provisional tolerable daily intake
PTWI	provisional tolerable weekly intake
QA/QC	quality assurance and quality control
RfD	reference dose
RMWI	recommended maximum weekly intake
TDI	tolerable daily intake

TD_{05}	tumorigenic dose at which the incidence of tumours (or death from tumours) is increased by 5%
the Project	Brucejack Gold Mine Project
TRV	toxicity reference value
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

1. Introduction

1. Introduction

Pretium Resources Inc. (Pretivm) is developing the Brucejack Gold Mine Project (the Project) in northwest British Columbia. The area is relatively remote. Local people, including First Nations, consume country foods in the general region of the Project as part of their diet.

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 quality of country foods is directly related to the quality of the surrounding environmental media (e.g., soil, water, and vegetation). This report provides the concentrations of contaminants of potential concern (COPCs) in country foods and the estimated consumption rates of each food by the harvesters under baseline conditions (i.e., prior to Project construction). Calculations of the estimated daily intakes (EDIs), exposure ratios (ERs), hazard quotients (HQs), recommended maximum weekly intakes (RMWIs), and increased incremental lifetime cancer risk (ILCR) for country foods are also presented following Health Canada's guidance on health impact assessments (Health Canada 2010d).

In the past 15 years, there have been concerns raised regarding the quality of country foods in Canada as elevated concentrations of persistent organic pollutants (POPs), heavy metals, and radionuclides in wildlife tissue have been reported in undeveloped areas of Canada and the Arctic (INAC 2006).

POPs are human-generated chemicals, while radionuclides and metals are naturally occurring chemicals. Regardless of the chemical's source, there are concerns that humans who consume country foods may be exposed to unsafe chemical concentrations present in the edible portions of the food items.

For the Project, the primary contaminants of potential concern (COPCs) are most likely to be metals, given that the Project includes the development of a metal mine. As metals occur naturally in the surrounding environment (e.g., soil, water), Project activities could potentially change metal concentrations in environmental media. As a result, metal concentrations in plants and animal tissues could also be altered, which could have the potential to affect the health of human consumers of country foods. Thus a baseline assessment of health risk associated with consumption of country foods in the vicinity of the Project was warranted to support a subsequent environmental assessment process. This report presents the methods and results of a study conducted for the Project.

2. Project Description

2. Project Description

Pretium Resources Inc. (Pretivm) proposes to develop the Brucejack Gold Mine Project (the Project) as a 2,700 tonne per day (tpd) underground gold and silver mine. The Brucejack property is located at 56°28′20″ N latitude by 130°11′31″ W longitude, which is approximately 950 km northwest of Vancouver, 65 km north-northwest of Stewart, and 21 km south-southeast of the closed Eskay Creek Mine (Figure 2-1). The Project is located within the Kitimat-Stikine Regional District. Several First Nation and Treaty Nations have traditional territory within the general region of the Project including the Skii km Lax Ha, the Gitxan First Nation, the Nisg̱a'a Nation, the Gitanyow First Nation, and the Tahltan Nation.

The mine site area will be located near Brucejack Lake. Vehicle access to the mine site will be via an existing exploration access road from Highway 37 that may require upgrades to facilitate traffic during mine operations. A transmission line will connect the mine site to the provincial power grid near Stewart or along Highway 37; two options are currently under consideration.

The Project is located within the boundary range of the Coast Mountain Physiographic Belt, along the western margin of the Intermontane Tectonic Belt. The local terrain ranges from generally steep in the western portion of the Project area in the high alpine with substantial glacier cover to relatively subdued topography in the eastern portion of the Project area towards the Bell-Irving River. The Brucejack mine site will be located above the tree line in a mountainous area at an elevation of approximately 1,400 meters above sea level (masl); surrounding peaks measure 2,200 m in elevation. The access and transmission corridors will span a range of elevations and ecosystems reaching a minimum elevation near the Bell Irving River of 500 masl. Sparse fir, spruce, and alder grow along the valley bottoms, with only scrub alpine spruce, juniper, alpine grass, moss, and heather covering the steep valley walls.

The general area of the Brucejack Property has undergone mineral exploration since the 1960s. In the 1980s Newhawk Gold Mines Ltd. conducted advanced exploration activities at the current site of the proposed Brucejack mine site that included 5 km of underground development, construction of an access road along the Bowser River and Knipple Glacier, and resulted in the deposition of 60,000 m^3 of waste rock within Brucejack Lake.

Environmental baseline data was collected from Brucejack Lake and the surround vicinity in the 1980s to support a Stage I Impact Assessment for the Sulphurets Project proposed by Newhawk Gold Mines Ltd. More recently, Silver Standard Resources Inc. commenced environmental baseline studies specific to the currently proposed Project in 2009, which have been continued by Pretivm, following its acquisition of the Project in 2010. The scope and scale of the recent environmental baseline programs have varied over the period from 2009 to the present as the development plan for the Project has evolved.

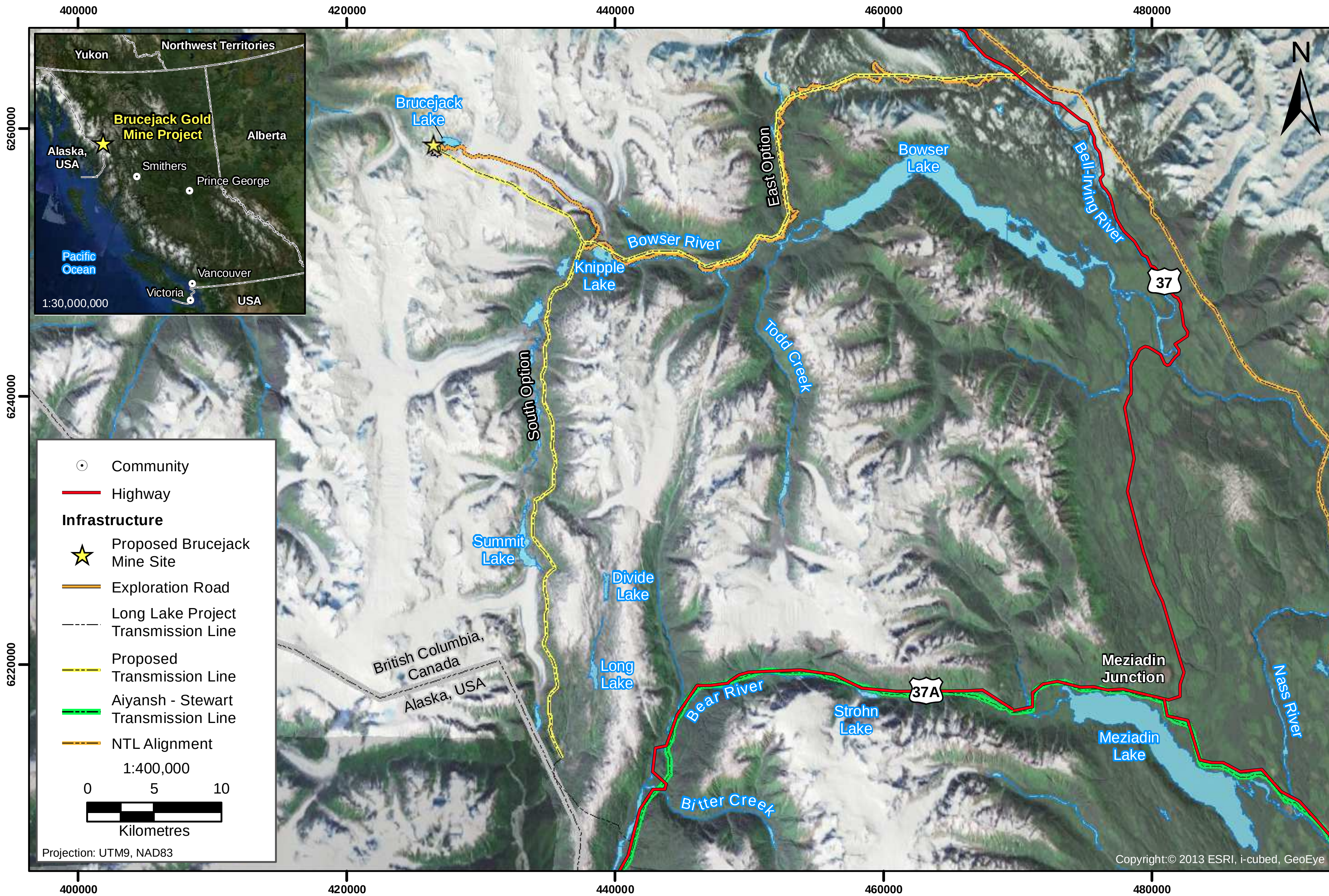

Figure 2-1

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Brucejack Gold Mine Project Overview

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3. Background Information

3. Background Information

3.1 APPLICABLE LEGISLATION

The inclusion of human health impact assessment, including potential effects on country food quality, in the environmental assessment (EA) process in Canada has been recognized by the federal government and by the Province of BC under various legislation and requirements (Health Canada 1999, 2010e).

Under BC's *Environmental Assessment Act* (2002), an environmental assessment certificate is required and the proponent may not proceed with the project without an assessment of whether the project has "a significant adverse environmental, economic, social, heritage or health effects." Under the *Canadian Environmental Assessment Act* (2012), the definition of an "environmental effect" includes any changes in health or socio-economic conditions that are caused by the project's environmental effects.

The province of BC (Environmental Assessment Office) typically relies on Health Canada to assess the adequacy of the human health impact assessment component of the environmental assessment. Health Canada provides some guidance on the type of information required to be included in the impact assessment for human health. For assessing the potential for contamination of country foods under baseline conditions, Health Canada indicates that the human health risk assessment should "consider adequate baseline data and/or modelling of COPCs in country foods prior to any project activities" (Health Canada 2010d). This country foods baseline assessment is intended to fulfill this requirement.

3.2 LITERATURE REVIEW

Data used in this country foods baseline assessment were obtained from recent and historical studies conducted in the area of the Project. Data sources reviewed to support this country foods baseline assessment include:

- 2012 Aquatic Baseline Report (Brucejack; Rescan 2013c)
- 2012 Fish and Fish Habitat Baseline Report (Brucejack; Rescan 2013b)
- 2012 Wetland Baseline Study (Brucejack; Rescan 2013f)
- 2012 Terrestrial Baseline Study (Brucejack; Rescan 2013e)
- 2012 Wildlife Characterization Baseline Report (Brucejack; Rescan 2013i)
- 2012 Socio-Economics Baseline Report (Brucejack; Rescan 2013d)
- Non-traditional Land Use Baseline Report (Brucejack; Rescan 2013a)
- Skii km Lax Ha Traditional Knowledge and Traditional Use Report (Brucejack; Rescan 2013h)
- 2007 to 2011 baseline water quality baseline data collected for the KSM Project
- 2009 fish and fish habitat baseline data collected for the KSM Project
- 2009 vegetation and ecosystem mapping baseline data collected for the KSM Project
- 2009 soil and terrain baseline data collected for the KSM Project
- 2009 wildlife characterization baseline data collected for the KSM Project
- Water and sediment quality data collected during 2012 by BGC Engineering Inc.

Exploration activities have been associated with several mineral deposits, including silver and gold deposits, in the vicinity of Brucejack Lake, Sulphurets Creek, and Mitchell Creek, since the 1880s. In the mid-1990's, previous exploration activities by Newhawk Gold Mines Ltd. on the Sulphurets Project entered a "care and maintenance" phase. By 1998, Newhawk Gold Mines Ltd. sought approval for the reclamation of the area though the underwater disposal of waste rock generated during explorations activities in Brucejack Lake to reduce environmental liability. While the disposal of mine waste into lakes is often not a preferred option due to potential impacts on fish, which are protected under the *Fisheries Act,* Brucejack Lake is classified as non-fish bearing (Price 2005).

Brucejack Lake discharges west via Brucejack Creek into Sulphurets Creek and eventually to the Unuk River. The aquatic ecosystems in these downstream areas (Sulphurets Creek and the Unuk River) have been extensively studied over recent years as part of baseline studies leading up to an environmental assessment for the Kerr-Sulphurets-Mitchell (KSM) Project, a development by Seabridge Gold Inc.

4. Objectives

4. Objectives

The main objective of this report is to determine what, if any, risk there is to human consumers of country foods collected from within the country foods study area of the Project. This report identifies which country foods harvesters are potentially the highest users of the area (and therefore would experience the highest potential risk from country foods consumption) and which country foods are gathered and consumed. The concentrations of COPCs within selected country foods were measured or estimated and a human health risk assessment was completed to determine the potential for health effects from consumption of selected country food items area under baseline conditions.

5. Study Area

5. Study Area

The country foods study area (Figure 5-1) is defined by a buffer extending to at least the height of land or 1.0 km buffer around the outer limits of the proposed infrastructure and linear developments. Watershed height-of-land borders are often used to define study areas, as they are physical barriers to transference (via water) of potential Project-related effects. Buffers around infrastructure are used to account for the potential effects of Project-related dust deposition. In addition, other physical features such as waterways were used to define country foods study area, when they were considered likely to be the limit of the potential future effects of the Project.

Waterways downstream of the Project mine site near Brucejack Lake (including Brucejack Creek, Sulphurets Lake, and much of Sulphurets Creek) are non-fish bearing due to the presence of a fish barrier (cascades) on Sulphurets Creek, located near the confluence with the Unuk River. The cascades are located approximately 20 km downstream of Brucejack Lake. Due to this considerable distance, and because any potential effects on surface water quality are likely to be restricted to a more localized area, the Project is not expected to result in adverse effects on fish and fish habitat in the Unuk River (Rescan 2013g). Therefore, the country foods study area includes non-fish bearing waterways downstream of the Project mine site as far as Sulphurets Creek, near the confluence with Ted Morris Creek, but excludes the fish-bearing waterways below the cascades on Sulphurets Creek and in the Unuk River.

For the purposes of this report, the country foods study area has been further broken down into three separate areas because of the variety of landforms and vegetation types present, the different types of effects that may result from the various infrastructure components, and the relatively large geographical separation among some of the infrastructure components. These three areas include the Access Road study area, the Mine Site study area, and the Transmission Line South Option study area (Figure 5-1). The Access Road has a climate that transitions from coastal at the western edge to continental at the eastern edge. The Mine Site study area is situated above the tree line in alpine and parkland ecosystems. The Transmission Line South Option study area extends from around the Premier mine site to the Project mine site.

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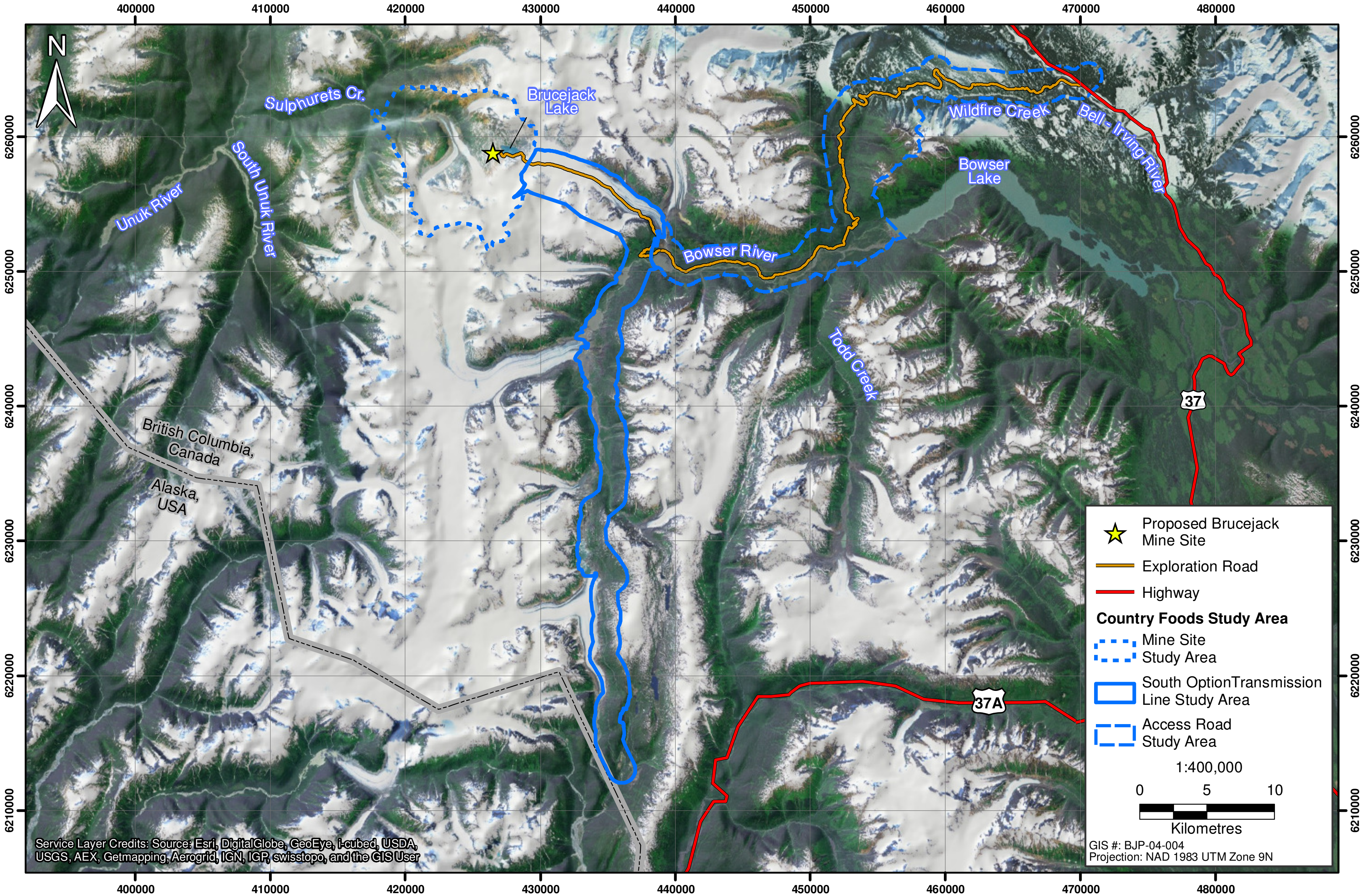

Figure 5-1

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Country Foods Study Area

Figure 5-1

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6. Approach

6. Approach

6.1 APPROACH OF COUNTRY FOODS ASSESSMENT

The approach for the country foods study was based on Health Canada's guidelines for assessing country food issues in environmental impact assessments (Health Canada 2010a, 2010c). As such, this study is divided into the following five stages:

1. Problem Formulation: The conceptual model for conducting the country foods risk assessment was developed in the problem formulation stage. This stage identified the COPCs and human receptor characteristics.
2. Exposure Assessment: The measured or predicted metal concentrations in country foods were integrated with human receptor 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 (exposure ratios, ERs). In addition, the recommended maximum weekly intake (RMWI) and increased incremental lifetime cancer risk (ILCR) for 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.

7. Problem Formulation

7. Problem Formulation

7.1 INTRODUCTION

The purpose of the problem formulation stage of the risk assessment is to create a conceptual model for the country foods baseline assessment. This stage identifies data requirements to accurately assess the potential for human health effects due to country food consumption collected from within the country foods study area. The objectives of the problem formulation stage are to:

- identify the most relevant country foods harvested within the country foods study area;
- identify the relevant COPCs within the country foods study area;
- identify the human receptors, characteristics and the relevant life stages (e.g., adults and toddlers) that may harvest or consume country foods; and
- identify the relevant human exposure pathways.

7.2 COUNTRY FOODS SELECTED FOR EVALUATION

Country foods include a wide range of animal, plant, and fungi species that are harvested for medicinal or nutritional purposes. The primary objective at this stage is to identify the most relevant country foods to evaluate. Key considerations when selecting the country foods to evaluate include:

- which country foods are currently collected in the country foods study area;
- how the country food is used (i.e., food, medicine, or both);
- what part of the country food is consumed (i.e., specific organs, plant leaves or roots);
- what quantities of each country food are consumed; and
- what the consumption frequencies are for each country food.

Typically in country foods studies, one species is selected from each of the following groups of foods: large mammals, small mammals, birds, fish, and vegetation. A species that represents the highest consumption level, and therefore results in the highest potential exposure to COPCs, is selected from within each of these groups. Theoretically, if foods that represent the highest rate of exposure are determined to be safe for consumption, then all other foods within the group would also be considered safe for consumption. The different groups are selected because the relative exposure of organisms in each group to the environmental media varies with specific habitat and foraging behaviours.

The country foods selected for this study were based on the findings presented in the *Skii km Lax Ha Traditional Knowledge Use Report* (Rescan 2013h) and Skii km Lax Ha Country Foods Consumption Questionnaire (Appendix A). The country foods study area is within the Skii km Lax Ha Asserted Territory (Figure 7.2-1). Among Gitxan First Nations wilps, Skii Km Lax Ha wilp is the only wilp that overlaps the country foods study area. Since Skii km Lax Ha's Asserted Territory encompasses all the country foods study area, country foods consumption data from the Skii km Lax Ha would be the most relevant and informative data for assessing the potential risk posed by country foods harvested from the country foods study area (Figure 7.2-2). For the Skii km Lax Ha, hunting, trapping, fishing, and plant, berry, and mushroom harvesting are important activities based on cultural practices and financial necessities (see Figure 7.2-5; Rescan 2013h; Appendix A). Rescan provided a written Skii km Lax Ha Country Foods Consumption Questionnaire, which was completed by Chief Darlene Simone of the Skii km Lax Ha. The results of this interview were incorporated in this assessment and are shown in Appendix A.

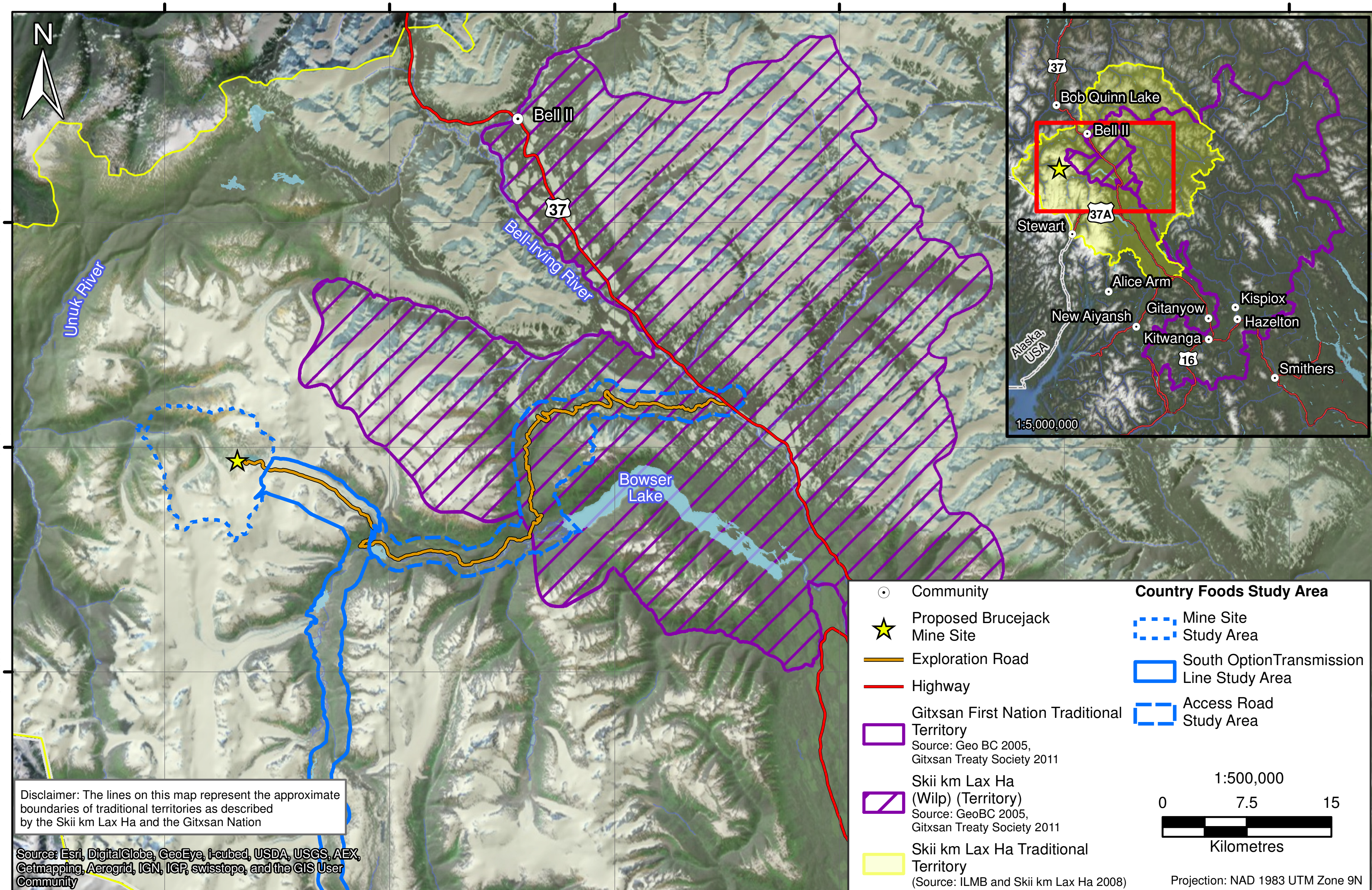

Figure 7.2-1

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Skii km Lax Ha and Gitxsan Traditional Territory and Country Foods Study Area

Figure 7.2-1

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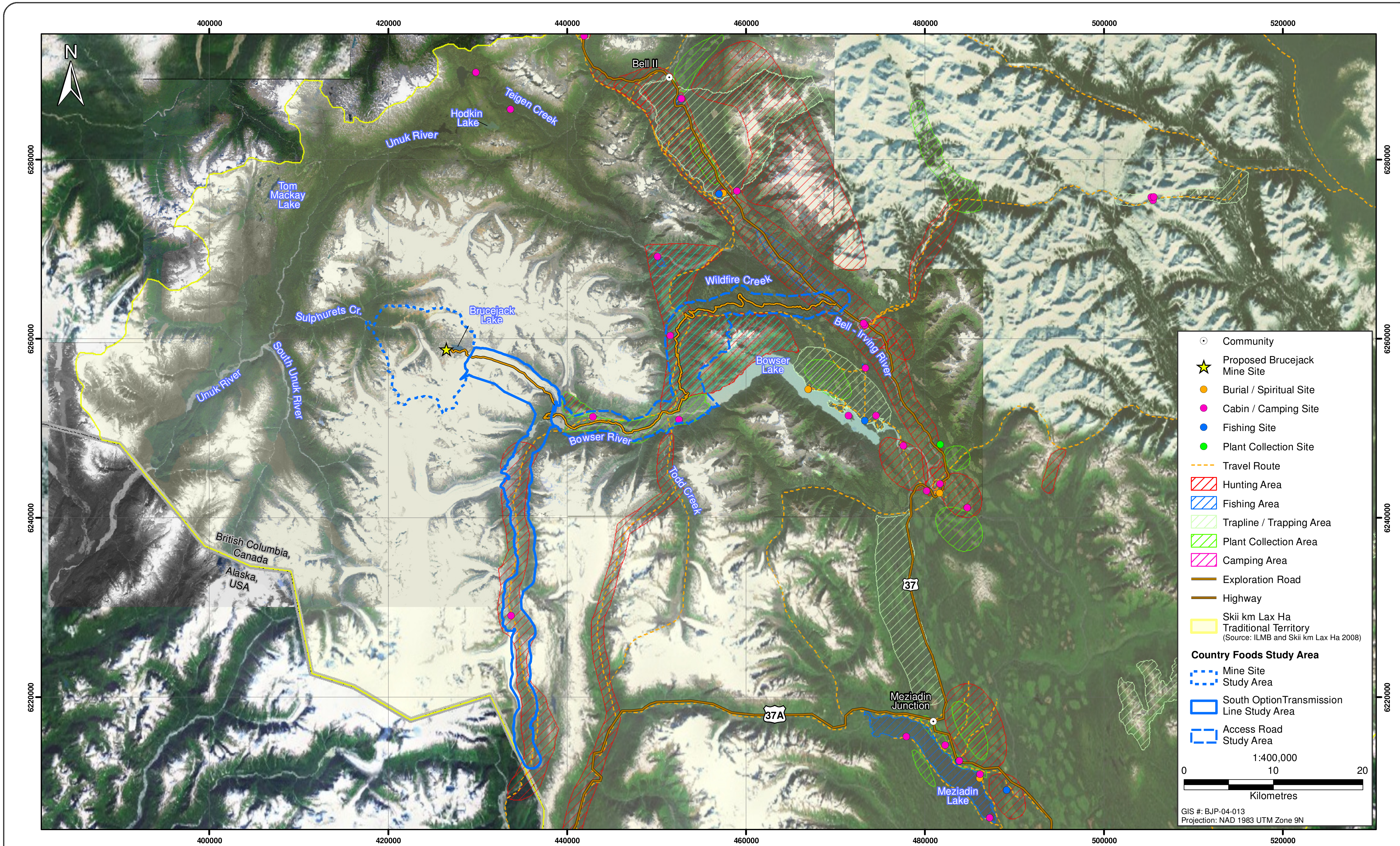

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Figure 7.2-2

Skii km Lax Ha Traditional Knowledge and Use Sites in Relation to Country Foods Study Area

Nisga'a Nation territories as defined in the *Nisga'a Final Agreement* and the Tahltan First Nations traditional territory have limited overlap with the country foods study area, while Gitanyow First Nations traditional territory is in close proximity of the country foods study area (Figures 7.2-3, 7.2-4, and 7.2-5). Since country foods consumption information was available for the Tahltan First Nation (Jin 2006), Tahltan First Nation consumption data was also included in this assessment. Currently, there are no consumption data available for the Nisga'a Nation. If this information becomes available at a later date it will be incorporated into future assessments of country foods quality and human health risk.

The country foods study area is also used by local hunters and guide outfitting companies (Rescan 2013a); however, First Nations and Nisga'a consumption of country foods is assumed to be higher than other resident and non-resident users (Health Canada 2010d). Assessing the group(s) with the highest consumption rates provides the most conservative estimate of the potential human health risk to all consumers since groups with lower consumption rates would have a lower level of exposure and lower risk.

7.2.1 Terrestrial Wildlife Species

7.2.1.1 Large Terrestrial Mammals

Moose (*Rangifer tarandus*) are the most commonly harvested large terrestrial mammal by the Skii km Lax Ha from the country foods study area, though black bear, grizzly bear, deer, mountain goat, and caribou are also hunted (Rescan 2013a). One hunting cabin is located along Bell-Irving River at Skowill Creek, south of the Bell-Irving River and Wildfire Creek confluence, with close proximity to the country foods study area (Rescan 2013h). Moose are harvested all along the Bell-Irving River valley (Rescan 2013h). As such, moose were selected for evaluation in this study.

Individual moose may migrate seasonally, the timing of which is dependent on weather events such as snowfall (Rescan 2013i). Approximately 71% of the moose population in the nearby Nass Wildlife Area (NWA) was identified as migratory individuals, with bulls and cows moving considerable distances between seasonal ranges within the NWA (Demarchi 2000). Migratory moose have a mean multiannual home range of 218 km^2 while non-migratory moose have a mean multiannual home range of 42 km^2 (Demarchi 2000).

During winter moose surveys conducted in 2011 for the Project, a total of 14 moose were estimated to be present in the coastal survey area and 160 moose in the interior survey area (Rescan 2013i). In general, the density of moose was 0.42 moose per km^2 in the interior survey area, which was more than twice as high than in the coastal survey area (0.24 moose per km2; Rescan 2013i). The interior survey area overlaps with the country foods study area to the west of Bowser Lake, along Wildfire Creek and a small section of the Bell-Irving River (Figure 7.2-6) while the coastal survey area does not overlap with the country foods study area.

For country foods baseline assessments it is preferable to consider species with ranges completely within the area of specific interest (i.e. country food study area). While moose do migrate over large areas outside of the country foods study area, their importance to the diet of local people supports their inclusion for assessment in this study.

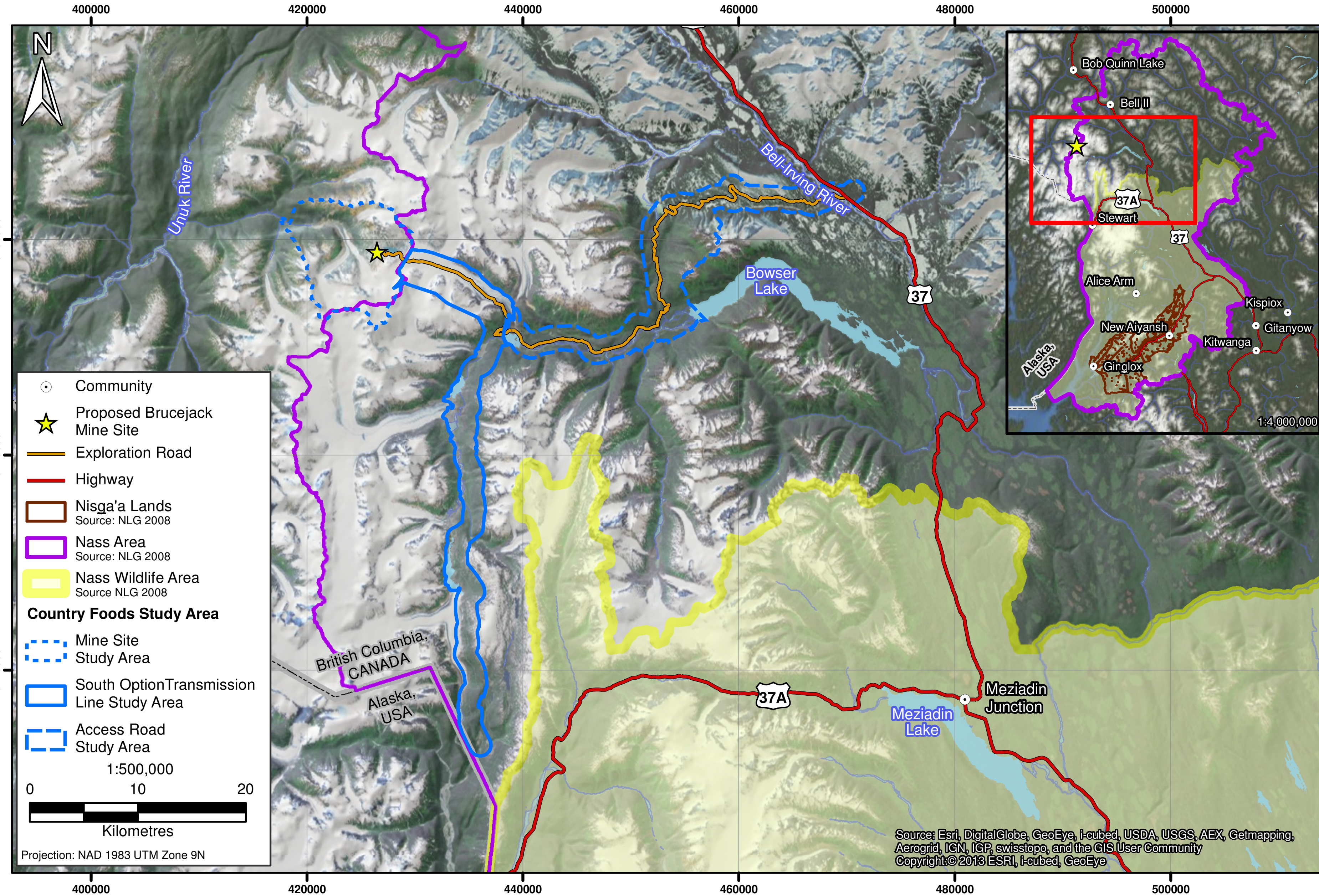

Figure 7.2-3

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Areas defined under the Nisga'a Final Agreement and the Country Foods Study Area

Figure 7.2-3

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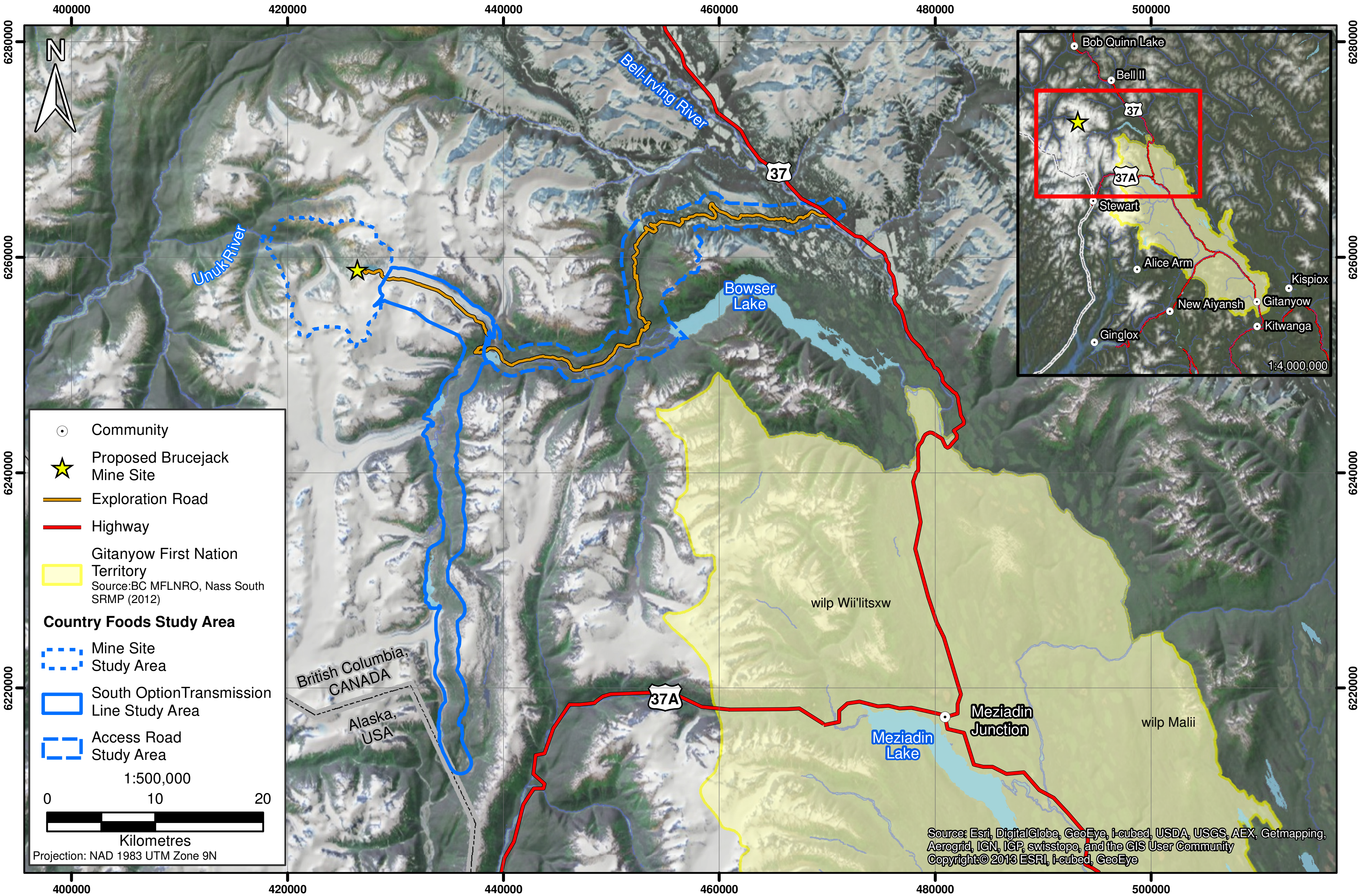

Figure 7.2-4

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Gitanyow Nation Traditional Territory and Country Foods Study Area

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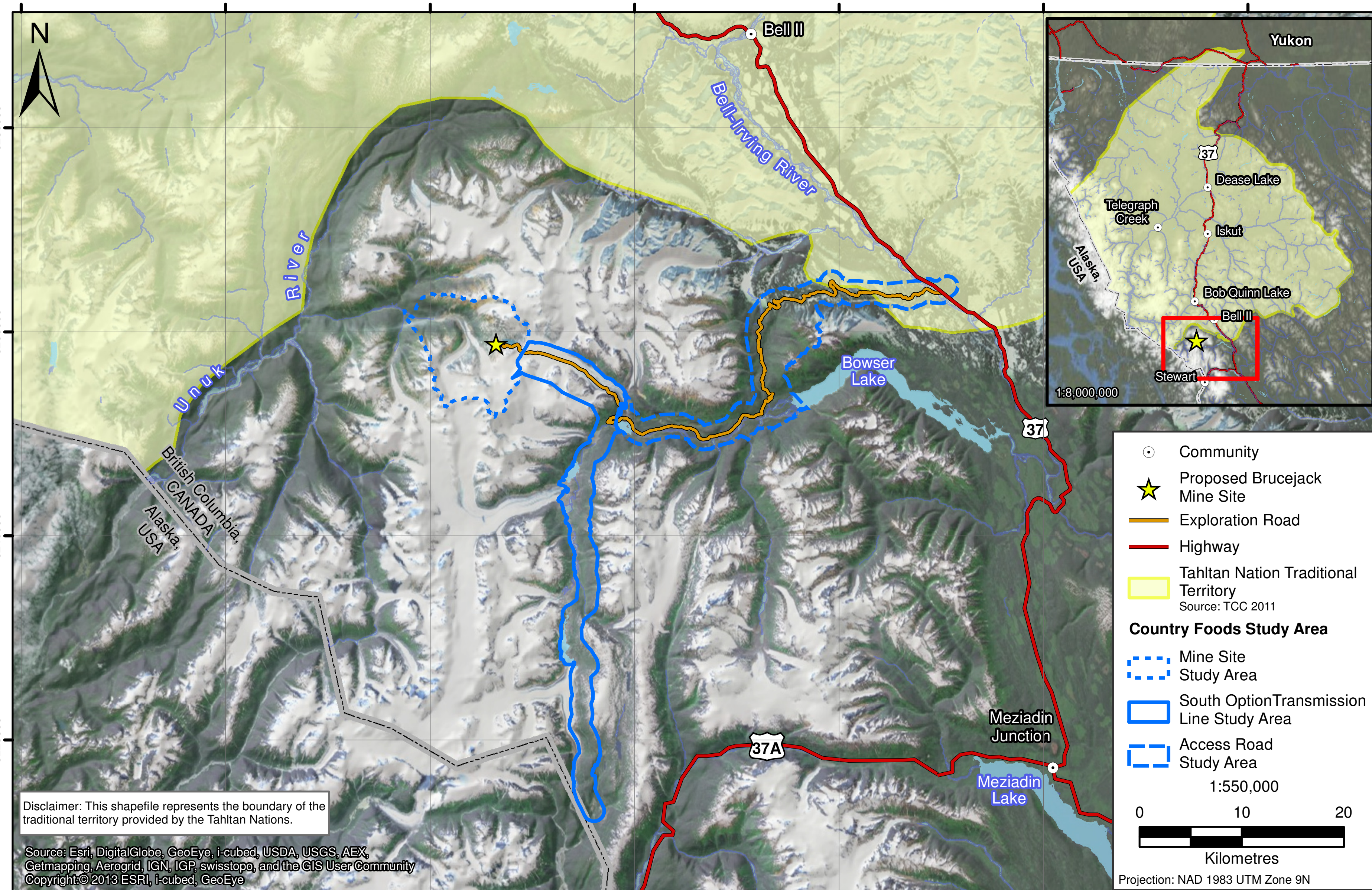

Figure 7.2-5

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Tahltan Nation Traditional Territory and Country Foods Study Area

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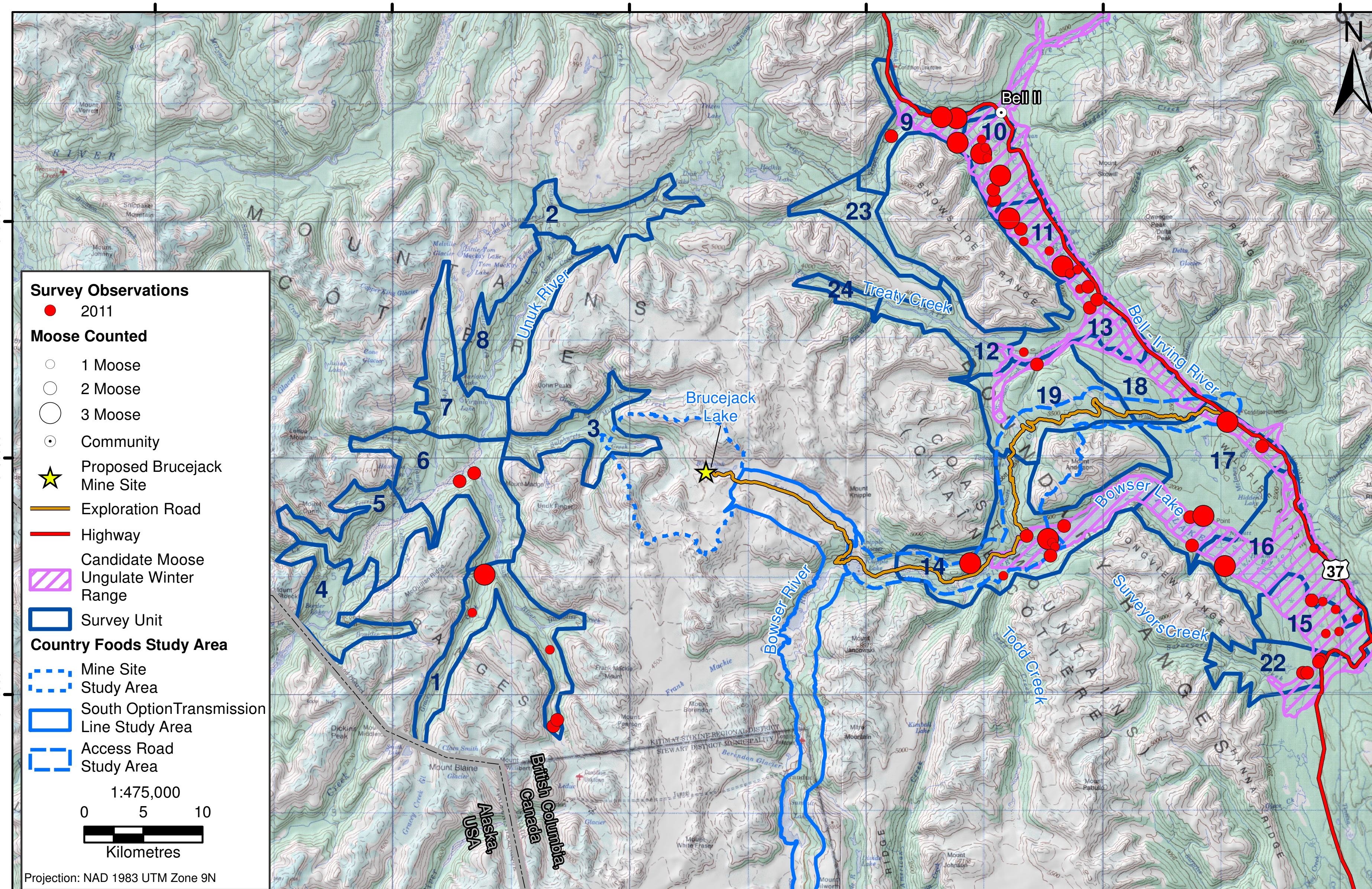

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Figure 7.2-6

Moose Winter Observations in Relation to Country Foods Study Area

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7.2.1.2 Small Terrestrial Mammals

The Skii km Lax Ha actively trap for species such as beaver, marten, hoary marmot, wolverine, and hare along the Highway 37 corridor (Rescan 2013h). Near the country foods study area, a hare snaring area is located near the confluence of the Bowser and Bell-Irving rivers. The home range of snowshoe hares is small and estimated to be between 0.057 to 0.1 km^2 (Adams 1959). The Skii km Lax Ha Country Foods Questionnaire (Appendix A) indicated that snowshoe hare, beaver, and hoary marmots are all consumed at similar frequencies. For country foods assessments, it is preferable to use organisms that have small home ranges that may be located entirely within the country foods study area. As such, snowshoe hare were included in the country foods baseline assessment.

7.2.1.3 Birds

Avian species including greater scaup (*Aythya marila*), ringed necked duck (*A. collaris*), mallard (*Anas platyrhynchos*), and Canada goose (*Branta Canadensis*) are among the waterfowl species observed during the waterbird surveys conducted in 2012. Ruffed grouse (*Bonasa umbellus*) and sooty grouse (*Dendragapus obscurus*) were observed during the breeding bird surveys in areas that overlap with the country foods study area (Rescan 2013i). Although spruce grouse (*Facipennis Canadensis*) was not observed during the breeding bird surveys for the Project, they were among species incidentally observed for the KSM Project. Grouse, ducks, ptarmigan, Canada goose, common loon, and mallard are hunted by the Skii km Lax Ha First Nation (Rescan 2013h). Although Skii km Lax Ha may consume ducks at slightly higher frequency than the other avian species (Appendix A), due to their migratory nature, ducks may not be the best representative of the avian species within the country foods study area.

Most grouse have a relatively small home range and, with the exception of sage grouse, are not known to migrate (Parks Canada 2011). It was assumed that grouse have a home range of 0.4 km^2 (spruce grouse; Ellison 1971). As metal exposure from the country foods study area would be most relevant to non-migratory foraging birds, consumption of grouse would likely represent the highest exposure to metals in birds harvested from the country foods study area. Since Skii km Lax Ha hunt grouse within the country foods study area, grouse was selected for inclusion in the country foods baseline assessment.

7.2.2 Fish Species

Fishing is a traditional activity that is undertaken by the Skii km Lax Ha along the Bell-Irving River near Treaty Creek, as well as areas on the Nass River (Rescan 2013h). Skii km Lax Ha fish for Dolly Varden (*Salvelinus malma malma*), spring salmon (chinook; *Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), mountain whitefish (*Prosopium williamsoni*), steelhead and rainbow trout (*O. mykiss*), and oolichan (*Thaleichthys pacificus*; Appendix A).

Based on historical data and recent baseline studies, species that may be caught in the country foods study area include spring salmon, sockeye salmon, steelhead, and rainbow trout, coho salmon, and spring salmon (O. Tshawytscha; Barbeau and Benyon 1950; Rescan 2013h). Within the country foods study area, steelhead and rainbow trout are fished along the Bell-Irving River between Treaty and Wildfire creeks (Rescan 2013h). Other current fishing areas include Oweegee Creek, the Cranberry River, and Meziadin Lake (Rescan 2013h), none of which are within the country foods study area.

Dolly Varden, bull trout (*S. confluentus*), coho salmon, chinook salmon, sockeye salmon, rainbow trout, and mountain whitefish were captured during baseline studies in various waterbodies near the Project (Rescan 2013b). Rainbow trout and coho salmon were found in the Bell-Irving River, Bowser River, Todedada Creek, and Wildfire Creek watersheds but not in the Todd Creek or Scott Creek watersheds

(Rescan 2013b). Chinook salmon were only captured in the Bell-Irving River, Bowser River, and Wildfire Creek mainstems (Rescan 2013b).

Fish barriers were located on Sulphurets, Scott, and Wildfire creeks (Rescan 2013b). The fish barrier on Sulphurets Creek is outside of country foods study area and consists of a set of cascades located approximately 300 m upstream from the confluence with the Unuk River. Fish are present at the mouth of Sulphurets Creek and within the Unuk River. The section of Sulphurets Creek from the confluence with Ted Morris Creek upstream to the Sulphurets Glacier was included in the country food study area. No fish have been observed in any of the creeks upstream of the cascades on lower Sulphurets Creek, including upper Sulphurets Creek, Sulphurets Lake, Brucejack Creek, and Brucejack Lake (Rescan 2013b). Scott Creek is inside of the country foods study area. Historically, no fish have been caught more than 5.2 km upstream of the mouth of Scott Creek (Coombs 1988; Saimoto and Saimoto 1998). Fish may be prevented from reaching the upper portion of the creek by impassable falls, cascades, and rapids. The barrier on Wildfire Creek is a cascade of small waterfalls approximately 2 km upstream of the confluence with the Bell-Irving River (Rescan 2013b). While smaller than the Sulphurets Creek fish barrier, no fish have been captured above the cascade of waterfalls 2 km upstream of the creek mouth.

Char species (Dolly Varden and/or bull trout) were captured in every studied watershed within the country foods study area and were the most abundant and widely distributed fish (Rescan 2013b). As such, Dolly Varden and bull trout were included as the representative fish species in the country foods assessment. It is important to note that chinook, sockeye, coho salmon and rainbow trout are identified to be fished on a more regular basis when compared with Dolly Varden/bull trout (Appendix A). However, Dolly Varden and bull trout are large-bodied fish that live for several years and have both anadromous and resident forms, with the resident type showing generally limited movement and dispersal within stream systems (Bryant and Luckey 2004; Ihlenfeldt 2005). These species possess short- to medium-term longevity (8 to 9 years), prey preference is benthic invertebrates, the age and length at maturation are short (3 to 5 years; 130 to 162 mm), and spawning is site-specific (Ihlenfeldt 2005; McPhail 2007). Therefore, tissue residues in Dolly Varden/bull trout are more likely to better represent contaminant loads derived from the study area than non-resident migratory fish species such as salmon and oolichan. Figure 7.2-7 presents the fish tissue metal sampling location within the country foods study area.

Dolly Varden and bull trout are very similar in appearance since they are closely related and have been known to inter-breed resulting in hybrids although no evidence of hybridization was found based on genetic analysis for the fish sampled from Scott Creek (Rescan 2013b). Eleven Dolly Varden or bull trout were sampled for tissue metal residue analysis from Wildfire Creek downstream of the fish barrier during 2011 and 2012 baseline studies (Rescan 2013b). However, since no genetic analysis was conducted on these fish and it is difficult to visually identify the species with high confidence, the sampled fish are referred to here as Dolly Varden/bull trout.

7.2.3 Plant Species

Typically in country foods studies, a vegetation species is selected as a country food for direct human consumption. In addition, where wildlife metal tissue concentrations are not available, models require metal concentrations in vegetation to model the metal concentrations in wildlife. Therefore, vegetation metal concentration data can be part of the country foods assessment both as a direct contribution (i.e., direct ingestion of vegetation) or as an indirect contributor through the consumption of wildlife (i.e., intake of vegetation by wildlife and subsequent intake by humans).

The Skii km Lax Ha are known to harvest berries and other plants in the general region surrounding the Project (Appendix A; Rescan 2013h). Harvested species include blueberries, cranberries, salmonberries, soapberries, Devil's Club, dandelions, fiddlehead, and wild onion roots (Appendix A; Rescan 2013h). From previous studies, several contemporary berry and pine mushroom sites have been identified (Rescan 2013h). Plant collection areas within the Brucejack country foods study area are located to the west of Bowser Lake overlap the country foods study area (Figure 7.2-2; Rescan 2013h). Therefore, consumption of vegetation from the country foods study area is possible and a vegetation species was included in this baseline assessment.

Valley bottoms within the country foods study area are densely forested with mature stands of fir, Sitka spruce, cedar, hemlock, aspen, alder, and maple. A thick undergrowth of ferns, salmonberry, huckleberry, copperbrush, and Devil's Club is usually present (Robinson et al. 1997). A mixture of berries were collected from the country foods study area including Alaska blueberry (*Vaccinium ovalifolium*), thinleaf huckleberry (*V. membranaceum*), Canada Buffaloberry (*Sheperdia canadensis*), and bog blueberry (*V. uliginosum*), and were analyzed for metal concentrations (Rescan 2013e). Additional Alaska blueberry metal concentration data, collected in 2009 during baseline studies for Seabridge Gold Inc.'s KSM Project within the Brucejack Project country foods study area were also included in the assessment.

Overall, metal concentrations from 19 berry samples were included in the assessment. Figure 7.2-8 presents the locations of berry samples within the country foods study area.

To support food chain modelling of wildlife species, samples of lichen samples from two species of common lichen (*Cladina stygia* and *Stereocaulon paschale*) and water sedge leaf (*Carex Aquatilis*) were collected from the country foods study area in 2012 and analyzed for metal concentrations (Rescan 2013e, 2013f). Data from samples collected as part of environmental baseline programs for Seabridge Gold Inc.'s KSM Project were also used in the present country foods baseline assessment. This includes tissue metal data from willow leaf (*Salix spp.*), perennial herb leaf of Sitka valerian (*Valeriana sitchensis*), and thinleaf huckleberry leaf (V. membranaceum). Overall, metal concentration data from 15 lichen, 21 water sedge leaf, one willow leaf, six Sitka valerian leaf, and two thinleaf huckleberry leaf samples were included. Figure 7.2-9 presents the plant sampling locations within the country foods study area that were used for inputs to the food chain model for estimation of the wildlife (i.e., moose, snowshoe hare, and grouse) tissue metal concentrations (see Section 8.2).

7.2.4 Summary of Country Foods Selected for Evaluation

A summary of the country foods selected for evaluation is presented in Table 7.2-1.

Table 7.2-1. Country Foods Selected for Evaluation

Category	Country Food	Species Name
Large Mammal	Moose	*Alces alces*
Small Mammal	Snowshoe hare	*Lepus americanus*
Bird	Grouse	*Phasianidae* sp.
Fish	Dolly Varden/ Bull trout	*Salvelinus malma/S. Confluentus*
Vegetation	Berries	Mixture of berries[1]

[1] Consisted of Alaska blueberry, thinleaf huckleberry, bog blueberry, and Canada Buffaloberry.

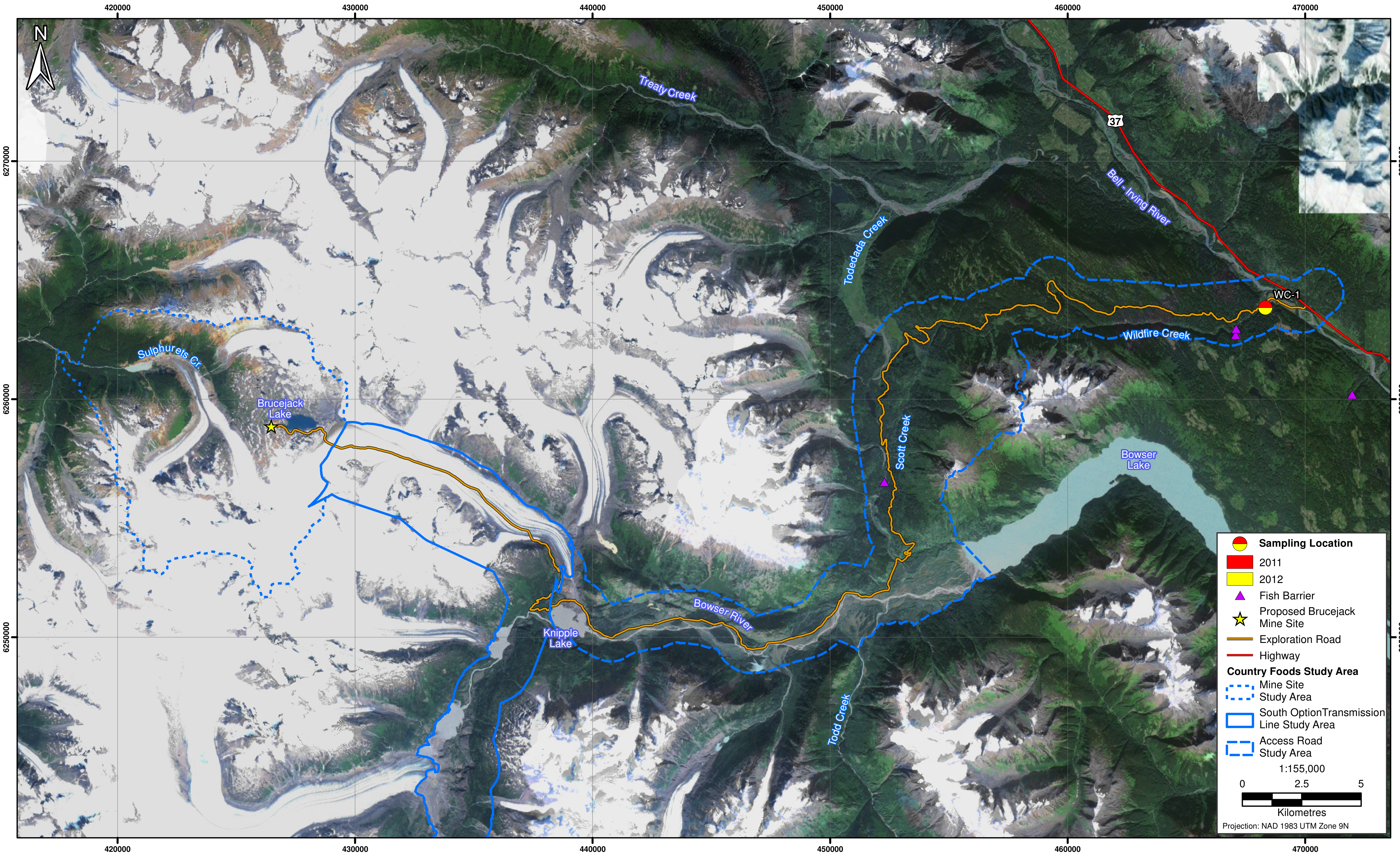

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Figure 7.2-7

Fish Tissue Sampling Location within the Country Foods Study Area

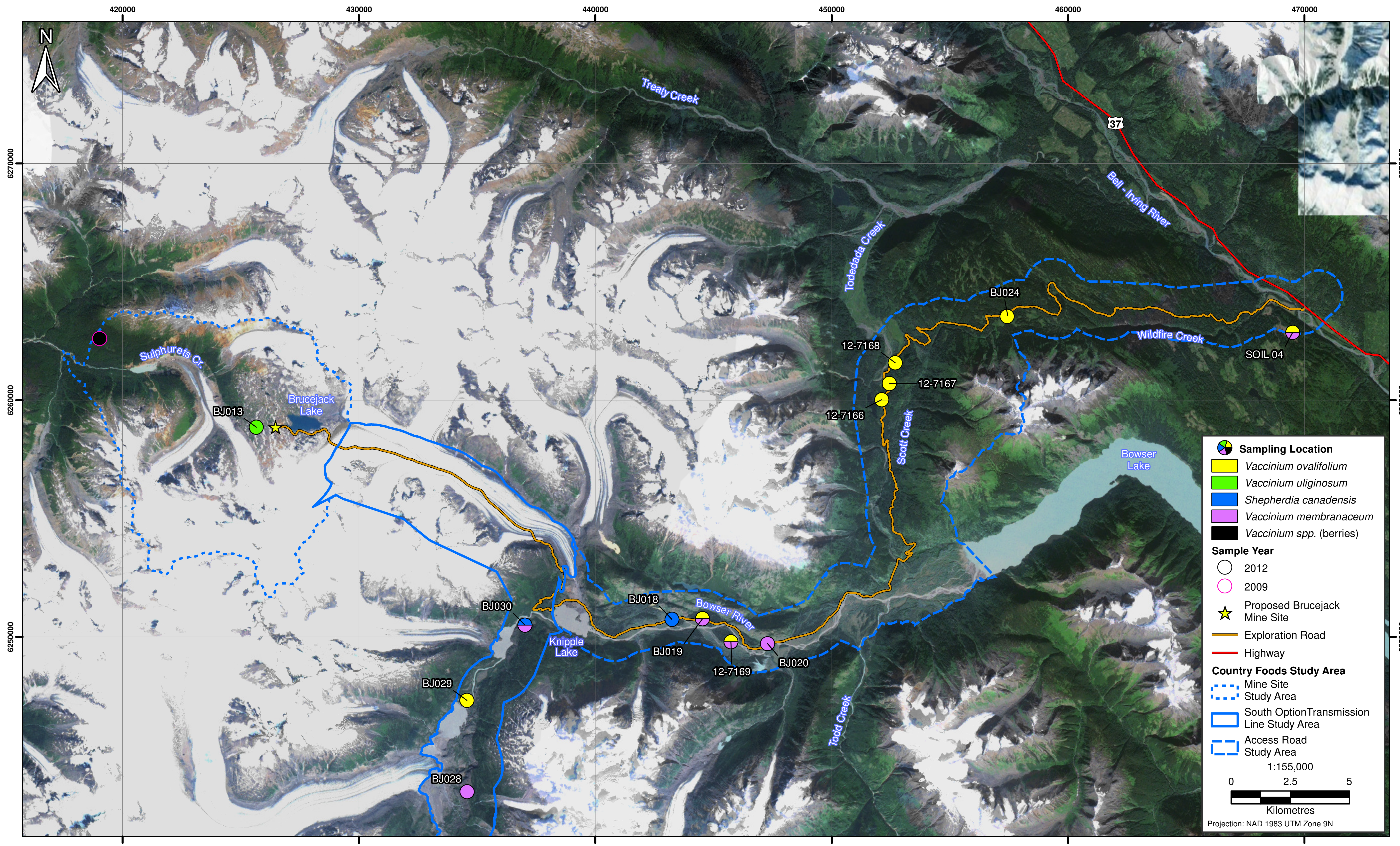

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Figure 7.2-8

Berry Sampling Locations within the Country Foods Study Area

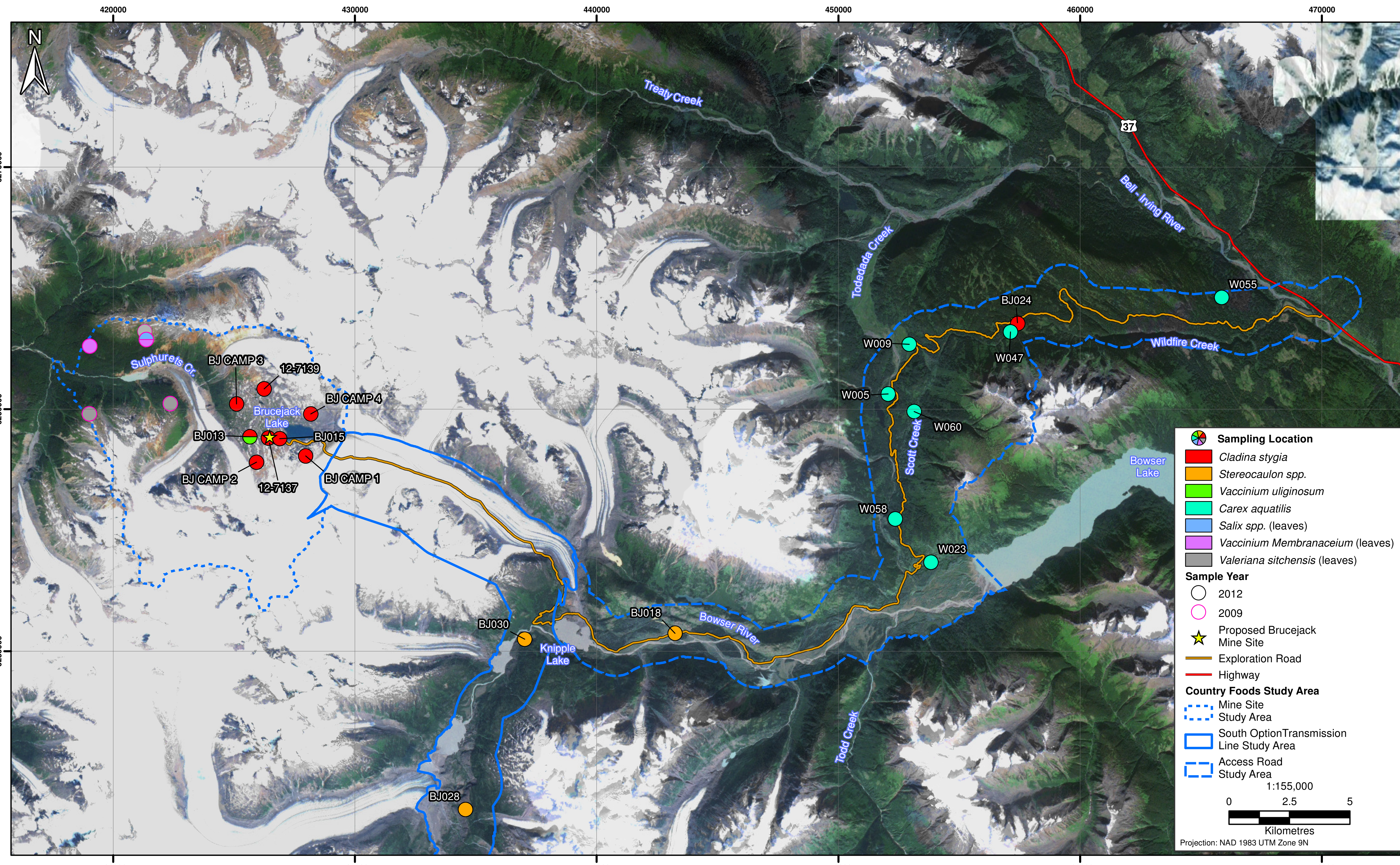

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Figure 7.2-9

Vegetation Sampling Locations to Support Food Chain Modelling

7.3 CONTAMINANTS OF POTENTIAL CONCERN

7.3.1 Criteria for Screening for Contaminants of Potential Concern

The country foods baseline assessment focused on metals as the COPCs since they naturally occur in environmental media (e.g., water, soil, sediment) due to local physical and geological processes and their concentrations could potentially change due to future Project activities. The present assessment did not consider other contaminants such as persistent organic pollutants (POPs) and radionuclides as these are not typically associated with metal mining, and are unlikely to be affected by Project related activities.

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

1. The maximum metal concentration in soil samples considered in the assessment exceeded its Canadian Council of Ministers of the Environment (CCME) soil quality guideline value for agricultural land (CCME 2012b).
2. The maximum total metal concentration in surface water samples included in the assessment exceeded its BC (maximum water criteria) or CCME water quality guideline value for the protection of aquatic life, whichever guideline was lower (BC MOE 2006a; CCME 2012c).
3. The maximum metal concentration in sediment samples considered in the assessment exceeded its CCME sediment quality guideline value for the protection of aquatic life (CCME 2012a) or CCME and BC interim sediment quality guidelines (ISQGs). If ISQGs were not available, screening level concentrations (SLC) were used (BC MOE 2006b).
4. The metal has a potential to bioaccumulate in organisms or biomagnify in food webs, such that there could be significant transfer of the metal from soil to plants and subsequently into higher trophic levels. Information on the bioaccumulation/biomagnification potential of each metal was obtained from a review of relevant documents from the Joint FAO/WHO Expert Committee on Food Additives (JECFA) and the US EPA (JECFA 1972a, 1982; US EPA 1997b; JECFA 2000; US EPA 2000; JECFA 2005, 2007, 2011).

Brucejack Lake, located within the Mine Site area, is located on high plateau above the treeline, covered by ice most of the year, and is highly inaccessible due to its elevation, climate, and absence of any roads that connect with Highway 37 other than the recently completed Project exploration road; it is unlikely that country foods are regularly available or harvested in this area. For most metals, concentrations were highest in the Mine Site study area in the various environmental media. Using the maximum metal concentrations from the environmental media for screening of the COPCs, including those from the Mine Site study area, provides a very conservative approach in the selection of the COPCs within the country foods study area.

7.3.2 Data from Environmental Media Included in the Assessment

The country foods study area encompasses Brucejack Lake, Bowser River, Wildfire Creek, and small portions of the Bell-Irving River and Sulphurets Creek (see Figure 5-1). Soil, water, and sediment baseline metal concentrations were compiled from baseline assessments conducted for this project as well as relevant KSM Project sampling sites within the country foods study area. Metal concentrations in soil samples included in this baseline assessment were collected from within the country foods study area (Rescan 2013e) in 2012. In addition, soil metal concentrations within the country foods study area as part of baseline studies at the KSM Project were also included in the assessment (Figure 7.3-1).

Metal concentrations in stream and lake water samples collected during Project baseline studies between 2007 and 2012 were included in the assessment (Rescan 2013c). However, elevated concentrations of metals in water were observed at the Adit sampling site, downstream of Brucejack Lake, and the Camp

Creek sampling sites within the Mine Site study area in late 2011 and 2012 compared to previous years (Rescan 2013c). Similarly elevated arsenic water concentrations were also noted at Brucejack Creek and Camp Creek sampling sites during the 2012 baseline studies compared to data collected in previous years. These higher concentrations may be associated with recent exploration activities initiated in May 1, 2011 (Rescan 2013c). Therefore, water quality samples from Brucejack Lake, Brucejack Creek, Camp Creek, and Adit, as well as the downstream sites form these areas including the Sulphurets Lake and Sulphurets Creek sites collected from May of 2011 to December 2012 were not included in the assessment as they may not reflect true water metal concentrations in baseline conditions.

Water quality data from sampling sites in KSM Project baseline studies that fall within the Project country foods study area from 2008 to 2012 were also included in this country foods baseline assessment (Figure 7.3-2). Historical water quality data within the Project country foods study area from 1987 to 2001 was not included in this assessment due to different collection methodologies and high detection limits (Newhawk Gold Minds Ltd. 1989; Price 2005)

Metal concentrations in sediments collected within the country foods study area from 2010 to 2012 (Rescan 2013c), in 2009 and 2012 from KSM Project within the country foods study area were also included in the assessment (Figure 7.3-2). Historical sediment quality data within the Project country foods study area was not included in this assessment due to different collection methodologies and high detection limits (Newhawk Gold Minds Ltd. 1989; Price 2005). Sediment metal concentrations were only used in the screening process for selecting COPCs. Sediment metal concentrations were not used for modelling purposes in this assessment since site-specific fish tissue metal concentrations were available and, therefore, models requiring sediment concentrations to predict fish tissue metal concentrations were not necessary.

The method detection limit (MDL) is the detectable concentration achievable by the analytical laboratory based on the chemistry of the sample. For the purpose of statistically summarizing the data, when metal concentrations in water or soil were below the MDL, a value of half the MDL was used.

7.3.3 Contaminants of Potential Concern Selected for Evaluation

Appendices B1, B2, and B3 present the statistical summaries of metal concentrations measured in samples of soil, surface water, and sediment from the country foods study area. Table 7.3-1 presents the metals identified as COPCs for inclusion in the country foods baseline assessment and which of the four criteria above were met to support their selection as COPCs. The COPCs selected for the country foods baseline assessment include: aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, tin, vanadium, and zinc.

Iron was not retained for further assessment as a COPC despite measured concentrations in surface waters and sediment exceeding CCME guidelines for the protection of freshwater aquatic life. Iron is an essential element as it is a required component in the blood cells for the transportation of oxygen throughout the body (Adriano 2001). Iron is the second most abundant metal in the earth’s crust and is abundant in soils and sediment where it is often tightly bound and not available for biological uptake. Iron toxicity in humans is very rare and most cases of acute poisoning have occurred when children accidentally consume large amounts of iron supplements (intended for adults) as they mistake the pills for candy (EVM 2003; Tenenbein 2005). Even with increased oral iron intake there is generally no significant iron overload in adults unless the individual has increased iron absorption because the ingested iron is in a highly bioavailable form, the individuals has an accompanying genetic defect, or the individual has increased demand due to a disorder such as anaemia (EVM 2003). Furthermore, adverse health effects from the ingestion of large amounts of iron have only been associated with iron supplements and not with iron in food (EVM 2003). Because iron is an essential element for humans and since environmental exposure to iron from food consumption is not likely lead to adverse health effects, iron was not evaluated further in this study.

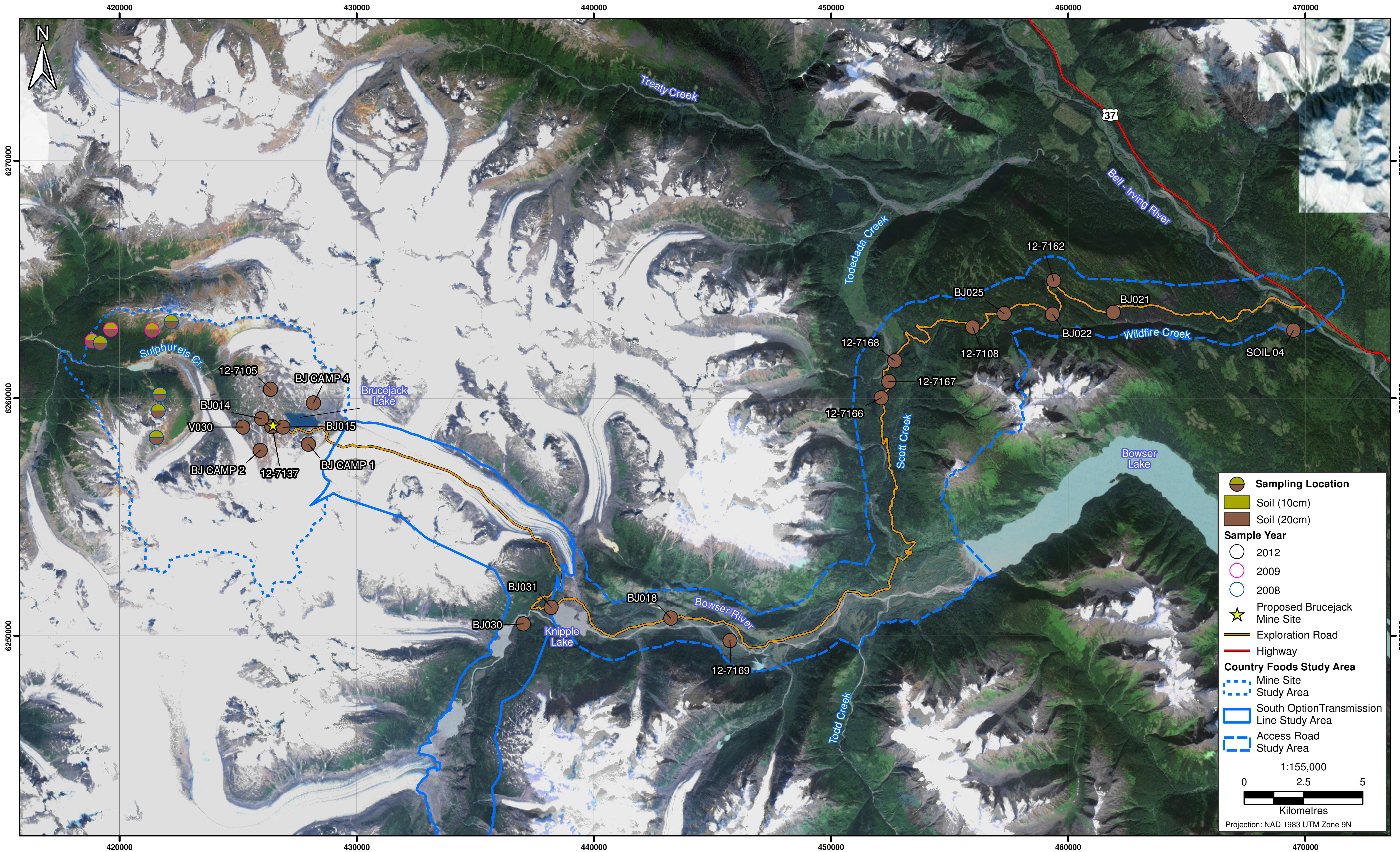

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Figure 7.3-1

Soil Sampling Locations within the Country Foods Study Area

Table 7.3-1. Metals Evaluated as Contaminants of Potential Concern

Metals	Maximum Soil Concentration n=31 mg/kg dry weight	CCME Soil Guideline (Agricultural) mg/kg dry weight	Maximum Sediment Concentration n = 36 to 157 mg/kg dry weight	CCME Sediment Guideline ISQG mg/kg dry weight	BC Sediment Guideline ISQG mg/kg dry weight	Maximum Water Concentration n = 164 to 169 mg/L	CCME Water Guideline Freshwater Aquatic Life mg/L	BC Max. Water Criteria Freshwater Aquatic Life mg/L	Inclusion
Aluminum	37900	-	30400	-	-	**10.6**	0.1	0.1	Y
Antimony	17.0	-	45.9	-	-	0.00405	-	-	N
Arsenic	**883**	12	**665**	5.9	5.9	**0.01**	0.005	0.05	Y
Beryllium	1.57	4	1.22	-	-	0.00025	-	-	Y
Bismuth	10	-	10.0	-	-	0.00025	-	-	N
Boron	nd	2	2.50	-	-	0.030	1.5	1.2	N
Cadmium	1	1.4	**8.71**	0.6	0.6	**0.000123**	0.0000038-0.000164[a]	-	Y
Calcium	30100	-	32500	-	-	76	-	-	N
Chromium	**118**	64	**135**	37.3	37.3	**0.0158**	0.0089	-	Y
Cobalt	**123**	40	56.0	-	-	0.00557	-	0.11	N
Copper	**1060**	63	**584**	35.7	35.7	**0.0360**	0.002-0.012[a]	0.0028-0.062[a]	Y
Iron	373000	-	**106000**	-	21200[b]	**12.9**	0.3	1	N
Lead	69.0	70	**250**	35	35	**0.0101**	0.001-0.034[a]	0.0033-0.87[a]	Y
Lithium	61.4	-	42.3	-	-	0.0301	-	-	N
Magnesium	15900	-	21400	-	-	7.19	-	-	N
Manganese	2400	-	5180	-	-	0.405	-	0.63-7.61[a]	N
Mercury	2.720	6.6	**0.810**	0.2	0.2	**0.000075**	0.000026	-	Y
Molybdenum	**154**	5	16.2	-	-	0.00224	0.073	2	Y
Nickel	**69.0**	50	**130**	-	16[b]	0.0107	0.025-0.39[a]	-	Y
Potassium	1820	-	3680	-	-	4.22	-	-	N
Selenium	**10.8**	1	**19.1**	-	5	**0.00208**	0.001	-	Y
Silicon	nd	-	nd	-	-	**24.4**	-	-	N
Silver	4.20	20	**89.0**	-	0.5[b]	**0.000201**	0.0001	0.003	Y
Sodium	1380	-	19900	-	-	33.0	-	-	N
Strontium	270	-	190	-	-	1.15	-	-	N
Thallium	**1.25**	1	2.14	-	-	0.00027	0.0008	-	Y
Tin	**6.80**	5	85.4	-	-	0.00018	-	-	Y
Titanium	1670	-	1700	-	-	0.417	-	-	N
Uranium	2.69	23	4.48	-	-	0.000263	0.2	-	N
Vanadium	**178**	130	159	-	-	0.0330	-	-	Y
Zinc	**208**	200	**581**	123	123	**0.0868**	0.03	0.033-0.45[a]	Y

Notes:

nd - not determined

[a] *Guideline is hardness-dependent and applicable range is providec*

Shaded cells indicate that the maximum metal concentration in that environmental media exceeds the relevant guidelines.

[b] *Lowest effect level based on SLC ; Nagpal, N. K. et al. 2006. A Compendium of Working Water Quality Guidelines for British Columbia. Science and Information Branch, Ministry of the Environment, Victoria, BC*

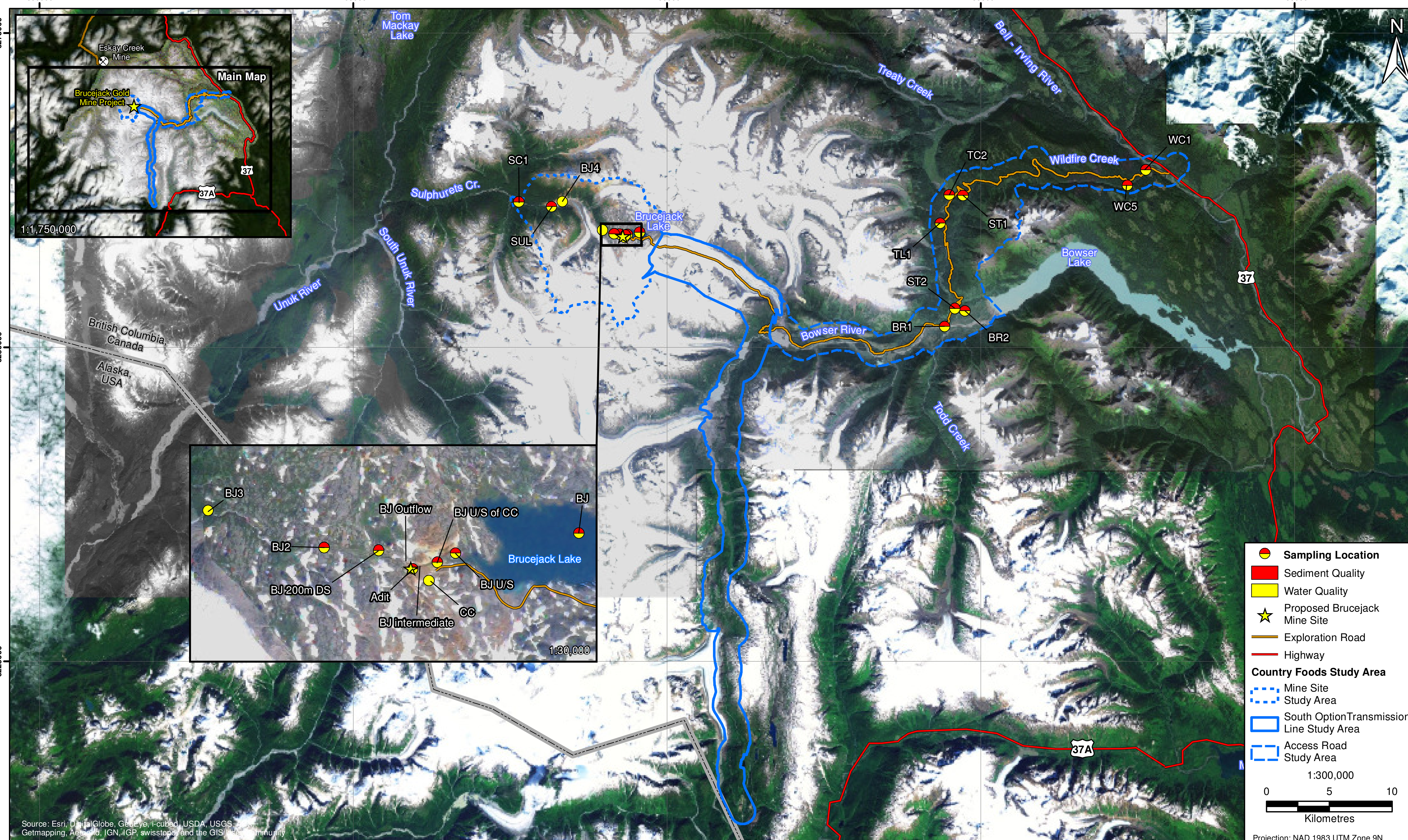

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Figure 7.3-2

Water and Sediment Sampling Locations within the Country Foods Study Area

7.4 HUMAN RECEPTORS

Chemicals that cause health effects are generally divided into two categories: threshold (i.e., non-carcinogenic) and non-threshold (i.e., carcinogenic) responses. These two categories of chemicals are evaluated differently and independently. Therefore, when selecting human receptors to evaluate, the types of chemicals that people may be exposed to must be considered.

The human receptors selected were toddlers (six months to four years of age) and adults (greater than 19 years of age). Toddlers are often most susceptible to chemicals with a threshold response due to their ratio of body size to ingestion rates (IRs) compared to other life stages (Health Canada 2010b, 2010c). Therefore, if an evaluation finds that COPC concentrations in country foods are unlikely to pose a health risk to toddler consumers, all other life-stages would be considered protected. An adult receptor was also selected for both threshold and non-threshold response chemicals based on guidance provided by Health Canada (Health Canada 2010d). In case of exposure to mercury, women of child-bearing age were also assessed as a sensitive group.

All major components of the proposed Project infrastructure (e.g., plant site, access road, and transmission corridors) lie within the Skii km Lax Ha Traditional Territory (Rescan 2013a). Of the Nisga'a Nation and First Nations with traditional territories in the region, the Skii km Lax Ha currently uses sites closest to the proposed Project infrastructure (Figure 7.2-2). Current Skii km Lax Ha activities in the region include hunting, trapping, plant collection, and fishing, and this information was used in the selection of which country foods to evaluate (see Section 7.2). In addition, the southernmost extent of the Tahltan Nation Traditional Territory overlaps the eastern portion of the Access Road portion of the country foods study area. Therefore, consumption data for the Tahltan Nation based on a study of Tahltan Nation traditional diet in the region (Jin 2006) was also included in this baseline study.

The Nass Area, as defined under the Nisga'a Final Agreement, also overlaps, the country foods study area; however, no consumption data from the Nisga'a Nation were available at the time of writing this report. Therefore, the country foods consumption was not assessed for Nisga'a Nation. If this information becomes available at a later date, it will be incorporated into future assessments of country foods quality and human health risk.

7.4.1 Human Receptor Characteristics

The human receptor characteristics used to calculate the estimated daily intake (EDI) of COPCs were body weight (kg), consumption amount (serving size), and consumption frequency (number of servings per year or servings per week of highest exposure) of the selected country foods. Tables 7.4-1 and 7.4-2 present summaries of the human receptor characteristics used in this baseline assessment.

The body weight for adults and toddlers were based on guidance provided by Health Canada (Health Canada 2010a). It was assumed that a toddler would eat country foods at the same frequency as adults, since toddlers most likely consume the same meals together with adults. The assumed toddler serving sizes were calculated as 43% of the adult serving sizes, as suggested by Richardson (1997). It is anticipated that this consumption overestimates the actual toddler serving sizes.

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 foods from the study area (Tables 7.4-1 and 7.4-2). Country foods ingestion rates (serving size) presented in Table 7.4-1 are based on a study on First Nation traditional diet in the region (Jin 2006) and these values were used in this baseline country foods assessment.

Table 7.4-1. Human Receptor Ingestion Rates

	Receptor Groups	
Receptor Characteristics	**Toddlers**	**Adults**
Body Weight (kg)[a]	**16.5**	**70.7**
Country Foods Serving Size (kg/serving)[b,c]		
Moose	0.0916	0.213
Snowshoe Hare	0.150	0.348
Grouse	0.129	0.299
Fish (Dolly Varden/Bull Trout)	0.12	0.279
Berries[d]	0.120	0.280

[a] Based on Health Canada guidelines (Health Canada 2010a).
[b] Based on First Nation traditional diet in the region (Jin 2006).
[c] Toddlers ingestion rates are assumed to be 43% of adult ingestion rates based on Richardson (1997).
[d] Includes Alaska blueberry, thinleaf huckleberry, bog blueberry, and Canada Buffaloberry.

Table 7.4-2. Human Receptor Consumption Frequencies

Receptors Characteristics	**Consumption Frequency**			
First Nation	**Skii km Lax Ha**		**Tahltan**	
Country Foods	**Number of Meals per Year[a]**	**Exposure Frequency (F)[a]**	**Number of Meals per Year[b]**	**Exposure Frequency (F)[b]**
Moose	156	0.427	364	0.997*
Snowshoe Hare	12	0.0329*	3	0.008
Grouse	12	0.0329*	6	0.016
Fish (Dolly Varden/Bull Trout)	12	0.0329*	7	0.019
Berries[c]	156	0.427*	12	0.033

Exposure frequency was calculated as a proportion of the number of days per year that a country food is consumed
** Indicates the more conservative human receptor exposure frequencies, which were used in this assessment.*
[a] Based on First Nation traditional diet in the region (Jin 2006).
[b] Based on Skii km Lax Ha Country Foods Questionnaire (Appendix A).
[c] Includes Alaska blueberry, thinleaf huckleberry, bog blueberry, and Canada Buffaloberry.

The consumption frequencies (meals per year) provided in Table 7.4-2 are based on the Skii km Lax Ha Country Foods Questionnaire (Appendix A), or the study by Jin (2006). The highest exposure frequencies shown in Table 7.4-2 (values with an asterisk) were selected for use in the assessment of each country food to ensure that risk estimates for consumption of COPCs in country foods was conservative.

7.5 HUMAN EXPOSURE PATHWAYS

Human exposure pathways are the routes by which people are exposed to chemicals. Food-related exposure pathways were selected for the country foods assessment based on the ingestion of:

- terrestrial animals that have taken up metals through the ingestion of soil, vegetation, and surface water;
- aquatic species that have taken up metals from their diet, sediments, and surrounding water; and
- plants that have taken up metals from the soil and water.

Human exposure pathways are illustrated along with sources of COPCs, residency media (e.g., terrestrial animals, fish, and vegetation), and exposure routes to human receptors in Figure 7.5-1. The conceptual model for this assessment is presented in Figure 7.5-2, which shows how metals in the environment move into the food chain and subsequently into humans through their diet.

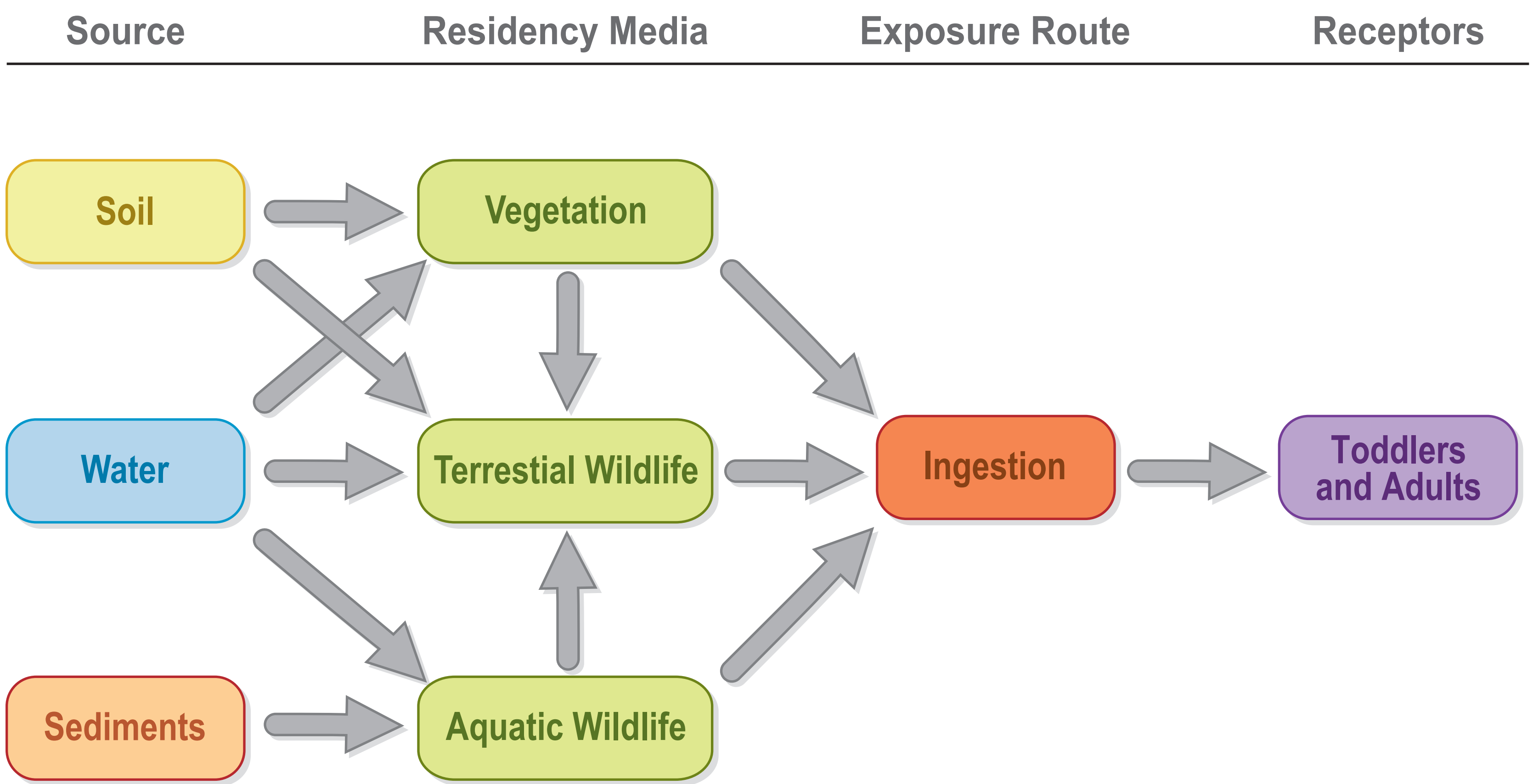

Figure 7.5-1

Human Exposure Pathways

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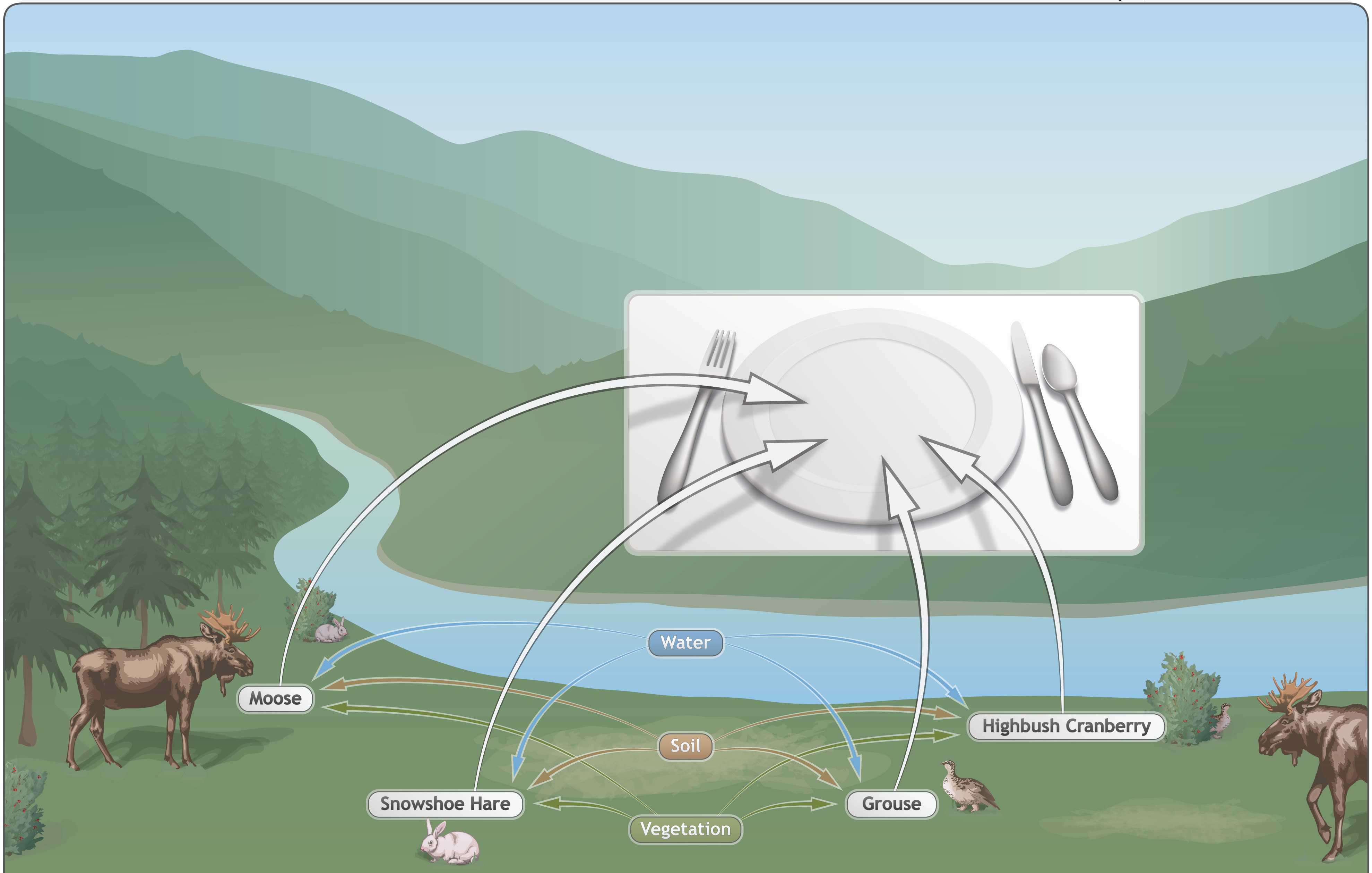

Figure 7.5-2

Country Foods Conceptual Model

8. Exposure Assessment

8. Exposure Assessment

8.1 INTRODUCTION

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

- the concentration of metals in terrestrial wildlife resulting from their ingestion of environmental media (e.g., vegetation, water, and soil);
- the concentration of metals in aquatic species resulting from their uptake of metals from water, sediment, and their diet;
- the concentration of metals in vegetation resulting from their uptake of metals from environmental media; and
- human receptor characteristics (e.g., consumption amount, frequency, body weight; described in section 7.4).

These parameters are included in the exposure estimate equations to determine the estimated daily intake (EDI) of each metal through the consumption of the selected country food. EDIs are based on the measured concentrations of metals in country foods, or modelled estimates based on metal concentrations in the environmental media.

8.2 TERRESTRIAL WILDLIFE TISSUE CONCENTRATIONS

No terrestrial wildlife species from the country foods study area were sacrificed to obtain tissue samples. Rather, moose, snowshoe hare, and grouse tissue metal concentrations were estimated using a food chain model described in Golder (2005). The model used the 95% Upper Confidence Limit of the Mean (UCLM) baseline metal concentrations in soil, water, berries, lichens, lichen, water sedge, willow, Sitka valerian, and berry leaves in addition to animal-specific ingestion rates and metal-specific biotransfer factors (BTFs; Appendix C, Table C2). The 95% UCLM provides a more balanced and realistic approach in estimating the metal concentrations in environmental media and the country foods when compared to the maximum concentrations, while providing a more conservative estimate of the metal concentrations when compared to the mean metal concentrations.

Each terrestrial wildlife species was assumed to take up metals from every environmental medium (soil, water, and vegetation). Appendix C describes the food chain model used to predict the tissue concentrations. Table 8.2-1 presents the modelled moose, snowshoe hare, and grouse muscle tissue concentrations for each of the COPCs.

8.3 FISH TISSUE CONCENTRATIONS

Eleven Dolly Varden/bull trout were collected from Wildfire Creek during baseline sampling in 2011 and 2012 within the country foods study area and were analyzed for tissue metal residues (Rescan 2013b). Table 8.3-1 presents tissue metal concentrations for the selected COPCs measured in Dolly Varden/bull trout samples. Appendix D1 provides a summary of the results for all metals analyzed in the Dolly Varden/bull trout tissue samples.

Table 8.2-1. Predicted Total Metal Concentrations in Terrestrial Wildlife from Exposure to Soil, Surface Water, and Vegetation

Metal	Moose	Grouse	Snowshoe Hare
Aluminum	6.68	1227	0.135
Arsenic	0.0580	8.84	0.00122
Inorganic Arsenic[a]	0.000450	0.0921	0.00000946
Beryllium	0.000887	0.0184	0.0000106
Cadmium	0.000732	0.00435	0.00000832
Chromium	0.0490	0.652	0.00102
Copper	0.703	7.87	0.0119
Lead	0.00204	1.38	0.0000361
Mercury	0.0438	0.000795	0.000649
Molybdenum	0.00477	0.250	0.0000896
Nickel	0.105	0.00226	0.00149
Selenium	0.00648	0.215	0.0000801
Silver	0.000595	0.182	0.0000140
Thallium	0.00619	0.021	0.0000942
Tin	0.104	0.124	0.00145
Vanadium	0.0403	0.00175	0.000836
Zinc	0.0194	0.0676	0.000223

All values expressed in mg/kg wet weight
[a] *Inorganic arsenic concentrations were estimated based on proportions of inorganic arsenic to total arsenic concentrations in Schoof et al. (1999) and were used in the country foods baseline assessments calculations. See Section 9.2.2 for further explanation.*

Table 8.3-1. Statistical Summary of the Total Metal COPC Concentrations in Dolly Varden/Bull Trout Tissue

Metals	Minimum	Mean	Maximum	95% UCLM
Aluminum	1.0	12	79.9	24.6
Arsenic	0.0120	0.0265	0.05	0.0334
Inorganic arsenic[a]	0.0012	0.00265	0.005	0.00334
Beryllium	nd	nd	nd	nd
Cadmium	0.0025	0.00395	0.00720	0.00507
Chromium	0.050	0.158	0.590	0.266
Copper	0.321	0.582	1.25	0.76
Lead	0.010	0.010	0.010	0.010
Mercury	0.0125	0.0242	0.0385	0.0289
Molybdenum	0.0050	0.0050	0.0050	0.0050
Nickel	0.050	0.066	0.140	0.0863
Selenium	0.520	0.83	1.04	0.912
Thallium	0.0050	0.00946	0.0240	0.0134

(continued)

Table 8.3-1. Statistical Summary of the Total Metal COPC Concentrations in Dolly Varden/Bull Trout Tissue (completed)

Metals	Minimum	Mean	Maximum	95% UCLM
Tin	0.0250	0.0364	0.109	0.0512
Vanadium	0.050	0.070	0.270	0.107
Zinc	5.06	7.31	10.8	8.33

nd - not determined
UCLM = Upper Confidence Limit of the Mean
All values expressed in mg/kg wet weight
[a] Inorganic arsenic concentrations in Dolly Varden/bull trout were estimated to be 10% of total arsenic concentrations based on Slejkovec, Bajc, and Doganoc (2004) and were used in the country foods baseline assessment calculations. See Section 9.2.2 for further explanation.

8.4 PLANT TISSUE CONCENTRATIONS

In total, 15 lichen samples of two common lichen species (*C. stygia* and *Stereocaulon spp.*), 19 berry samples (*S. canadensis*, *V. uliginosum*, *V. membranaceum*, and *V. ovalifolium*), 21 water sedge samples (*C. aquatilis*), 1 willow leaf sample (*Salix sp.*), 2 thinleaf huckleberry leaf samples (*V. membranaceum)*, and 6 flowering plant samples (*V. sitchensis*) were collected during baseline studies from within the country foods study area and analyzed for metal concentrations. Table 8.4-1 provides a summary of the COPC concentrations in vegetation used for the assessment. Appendix D2 summarizes the results for all vegetation tissue metals analyses.

The metal concentrations from all of vegetation tissue samples were pooled for use as vegetation input in the food chain model to estimate moose, snowshoe hare, and grouse tissue concentrations (see Appendix C). Berries were considered alone as a possible source of metal intake through direct human consumption.

8.5 ESTIMATED DAILY INTAKE

The estimated daily intake (EDI) of each COPC for toddlers and adults was based on the predicted (moose, snowshoe hare, and grouse) and measured (fish and berry) 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 (mg 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 is presented in Table 8.5-1. For this baseline assessment, it was assumed that 100% of the country foods consumed were harvested from the country foods study area and that 100% of the COPCs present in the foods were bioavailable; assumptions that are not entirely possible, and therefore provide a highly conservative estimate of the potential for risk to human health.

Table 8.4-1. Summary Metal Concentrations Measured in Vegetation Tissue Samples

	Berry[1]				Lichen[2]				Water Sedge[3], Willow[4], Flowering Plant[5], and Berry Leaves[6]			
	Minimum	Average	Maximum	95% UCLM	Minimum	Average	Maximum	95% UCLM	Minimum	Average	Maximum	95% UCLM
Aluminum	1	3.81	10.3	4.76	137	303	736	388	0.446	7.95	52.6	11.3
Arsenic*	0.005	0.005	0.005	0.005	0.0756	1.6	7.31	2.49	0.000675	0.0419	0.255	0.0579
Beryllium	0.294	2.1	5.28	2.58	6.06	20.3	57.3	26.9	0.572	10.4	25.1	12.5
Cadmium	0.0025	0.00574	0.0235	0.00808	0.0096	0.0496	0.109	0.0647	0.000338	0.134	1.74	0.251
Chromium	0.05	0.05	0.05	0.05	0.165	0.273	0.407	0.306	0.00675	0.182	0.250	0.215
Copper	0.418	0.839	1.47	0.956	0.95	2.05	5.65	2.56	0.0901	4.67	21.8	6.42
Lead	0.01	0.01	0.01	0.01	0.248	0.829	3.08	1.14	0.00135	0.0372	0.05	0.0437
Mercury	0.0005	0.000579	0.002	0.000716	0.0123	0.0338	0.0625	0.0401	0.00025	0.00250	0.00720	0.0030
Molybdenum	0.005	0.767	0.318	0.114	0.0332	0.0909	0.219	0.116	0.00780	0.21000	0.98900	0.2880
Nickel	0.05	0.335	2.42	0.567	0.408	1.18	3.65	1.57	0.0621	1.45	6.21	1.94
Selenium	0.1	0.1	0.1	0.1	0.021	0.0465	0.105	0.0559	0.0135	0.364	0.5	0.43
Thallium	0.005	0.005	0.005	0.005	0.00427	0.00831	0.025	0.0107	0.000675	0.0118	0.038	0.0143
Tin	0.025	0.153	0.386	0.191	0.0099	0.0262	0.0662	0.0331	0.00338	0.073	0.1	0.0861
Vanadium	0.05	0.05	0.05	0.05	0.196	0.75	1.66	0.896	0.00675	0.182	0.25	0.215
Zinc	0.77	1.62	3.26	1.89	5.29	12.4	20	14.6	0.364	29.4	64.7	35.4

All values expressed in mg/kg wet weight

[1] *Berry fruit samples were S. canadensis, V. uliginosum, V. membranaceum, and V. ovalifolium (n=19).*

[2] *Lichen samples were C. stygia, and Stereocaulon spp. (n=15).*

[3] *Water sedge samples were C. aquatilis (n=21).*

[4] *Willow samples were Salix spp. (n=1).*

[5] *Flower plants samples were V. sitchensis (n=6).*

[6] *Berry plants leaf samples were V. membranaceum (n=2).*

** Inorganic arsenic concentration in berries, lichen, water sedge, willow, flower plants, and berry leaves are 48% of the values indicated in the table. Inorganic arsenic concentrations in plants and berries were used in the country foods baseline assessment calculations. See section 9.2.2 for further explanations.*

Table 8.5-1. Estimated Daily Intake of Contaminants of Potential Concern by Human Receptors

COPC[a]	Estimated Daily Intake of COPC (mg/kg BW/day) by Adult Receptor				
	Moose	Grouse	Hare	Berries	Dolly Varden/ Bull Trout
Aluminum	0.0201	0.171	0.0000218	0.00798	0.00319
Arsenic[b]	0.00000135	0.0000129	0.00000000153	0.00000408	0.000000433
Beryllium	0.00000267	0.00000256	0.00000000172	0.0000861	nd
Cadmium	0.00000220	0.000000604	0.00000000135	0.0000132	0.000000657
Chromium	0.000147	0.00000906	0.000000166	0.0000851	0.0000344
Copper	0.00211	0.00109	0.00000192	0.00163	0.0000986
Lead	0.00000612	0.000193	0.00000000584	0.0000170	0.00000130
Mercury	0.000132	0.000000111	0.000000105	0.00000117	0.00000374
Molybdenum	0.0000143	0.0000347	0.0000000145	0.000202	0.000000649
Nickel	0.000316	0.000000315	0.000000241	0.000919	0.0000112
Selenium	0.0000195	0.0000298	0.0000000130	0.000170	0.000118
Silver	0.00000179	0.0000253	0.00000000227	nd	nd
Thallium	0.0000186	0.00000286	0.0000000152	0.00000861	0.00000173
Tin	0.000312	0.0000173	0.000000234	0.000310	0.00000664
Vanadium	0.000121	0.000000243	0.000000135	0.0000851	0.0000138
Zinc	0.0000583	0.00000940	0.0000000362	0.00320	0.00108
COPC[a]	Estimated Daily Intake of COPC (mg/kg BW/day) by Toddler Receptor				
	Moose	Grouse	Hare	Berries	Dolly Varden/ Bull Trout
Aluminum	0.0370	0.314	0.0000402	0.0147	0.00588
Arsenic[b]	0.00000249	0.0000236	0.00000000282	0.00000752	0.000000798
Beryllium	0.00000491	0.00000471	0.00000000316	0.000159	nd
Cadmium	0.00000406	0.00000111	0.00000000248	0.0000244	0.00000121
Chromium	0.000271	0.000167	0.000000305	0.000157	0.0000634
Copper	0.00389	0.00202	0.00000353	0.00301	0.000182
Lead	0.0000113	0.000355	0.0000000108	0.0000313	0.00000239
Mercury	0.000243	0.000000204	0.000000193	0.00000216	0.00000689
Molybdenum	0.0000264	0.0000640	0.0000000267	0.0000373	0.00000120
Nickel	0.000582	0.000000580	0.000000443	0.00169	0.0000206
Selenium	0.0000359	0.0000550	0.0000000239	0.000313	0.000218
Silver	0.00000329	0.0000466	0.00000000418	nd	nd
Thallium	0.0000343	0.00000527	0.0000000281	0.0000159	0.00000319
Tin	0.000575	0.0000318	0.000000431	0.000572	0.0000122
Vanadium	0.000223	0.000000448	0.000000249	0.000157	0.0000254
Zinc	0.000108	0.0000173	0.0000000666	0.00590	0.00199

nd = not determined
COPC = contaminants of potential concern
[a] COPCs EDIs are based on total metal concentrations unless otherwise stated.
[b] Arsenic EDIs are based on inorganic arsenic concentrations. See Section 9.2.2 for further explanation.

Appendix E presents a sample calculation of the EDI of arsenic for toddlers consuming moose tissue. An assessment of the EDIs in country foods shows that toddlers and adults had the highest EDI for chromium, copper, mercury, thallium, tin, and vanadium from consuming moose, the highest EDI of aluminum, arsenic, lead, and silver from consuming grouse, and the highest EDI of beryllium, cadmium, molybdenum, nickel, selenium and zinc from consuming berries. The lowest EDIs of COPCs were associated with the consumption of snowshoe hare and Dolly Varden/bull trout. It is important to note that the EDIs are based on the 95% UCLMs of metal concentrations measured in the environmental media and in the country foods. Therefore, these values are conservative in nature and may overestimate the true EDIs.

9. Toxicity Reference Value Assessment

9. Toxicity Reference Value Assessment

9.1 INTRODUCTION

The toxicity reference value (TRV) assessment involves determining the amount of a COPC that can be taken into the human body without experiencing adverse health effects. Toxicity information is typically derived from laboratory studies, where dose-response information is extrapolated from animal test subjects to humans by applying uncertainty or safety factors. In most cases, uncertainty factors of 100 to 1,000 are applied to the laboratory-derived no observed adverse effect levels (NOAELs). NOAELs are the highest concentration used in a toxicity test that results in no chronic health effects are observed or measured. These factors account for interspecies extrapolation and the protection of the most susceptible portion of the population (i.e., children and the elderly). Therefore, TRVs based on animal studies generally have large margins of safety to ensure that the toxicity or risk of a substance to people is not underestimated. Lowest observed adverse effect levels (LOAEL) from human studies have smaller uncertainty factors because no extrapolation from animals to humans is required.

The TRVs in this assessment are presented as Tolerable Daily Intakes (TDIs) or Provisional Tolerable Daily Intakes (PTDIs). The TDI is defined as the amount of metal per unit body weight (BW) 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.

Health Canada guidelines were used preferentially (i.e., Health Canada's Bureau of Chemical Safety, Chemical Health Hazard Division [CHHAD]) unless they were not available for certain COPCs, in which case alternative sources of guidelines were used. Other sources of guidelines included: United States Environmental Protection Agency's (US EPA) Integrated Risk Information System (IRIS) guidelines, Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) Joint Expert Committee on Food Additives and Contaminants (JECFA) guidelines, Health Effects Assessment Summary Table (US EPA 1997a), and toxicological profiles for metals from the Agency for Toxic Substances and Disease Registry (ASTDR). The TRVs used in this baseline assessment are presented in Table 9.1-1. It is noted that the US EPA uses the term reference dose (RfD) rather than TDI, but for consistency within the report, RfDs will be reported as TDIs. Toxicity studies on which the TDIs were based on and the rationale for their selection are briefly summarized in Section 9.2.

Table 9.1-1. Toxicity Reference Values for Contaminants of Potential Concern

Metals	TRV (mg/kg BW/day)	
	Adult	Toddler
Aluminum	1[a]	1[a]
Arsenic	0.0003[b]	0.0003[b]
Beryllium	0.0020	0.0020
Cadmium	0.0010	0.0010
Chromium	0.001	0.001
Copper	0.141	0.091

(continued)

Table 9.1-1. Toxicity Reference Values for Contaminants of Potential Concern (completed)

Metals	TRV (mg/kg BW/day)	
	Adult	Toddler
Lead	0.0036	0.0036
Mercury (Total)	0.0003[c]	0.0003[c]
Methylmercury	0.00047[d]	0.00023[e]
Molybdenum	28	23
Nickel	0.025	0.025
Selenium	0.0057	0.62
Silver	0.005[b]	0.005[b]
Thallium	0.00007	0.00007
Tin	0.6[f]	0.6[f]
Vanadium	0.009[b]	0.009[b]
Zinc	0.57	0.48

TRV = toxicity reference value
[a] ATSDR (2008). Toxicological Profile for Aluminum. U.S. Department of Health and Human Services. Public Health Services. Agency for Toxic Substances and Disease Registry
[b] US EPA (2013). Integrated Risk Information System. Online: www.epa.gov/iris
[c] Total mercury TRV for adults and toddlers eating biota other than fish.
[d] Methylmercury TRV for general public eating fish.
[e] Methylmercury TRV for children, women of child-bearing age, and pregnant women eating fish.
[f] US EPA (1997a). Office of Research and Development. Health Effects Assessment Summary Tables. July 1997.
All other TRVs from Health Canada (2010b)

9.2 TOXICITY REFERENCE VALUES

9.2.1 Aluminum

Health Canada (2011) provides a PTDI of 0.3 mg/kg BW/day for aluminum. No rational is provided for the derivation of this PTDI. The Joint FAO/WHO Expert Committee on Food Additives provides an estimate for a provisional tolerable weekly intake (PTWI) of 1 mg/kg BW (JECFA 2007). ATSDR (2008) has derived an intermediate-duration and a chronic-duration oral minimal risk level (MRL) of 1 mg Al/kg BW/day for aluminum. The chronic-duration MRL is based on a LOAEL of 100 mg Al/kg BW/day for neurological effects in mice exposed to aluminum lactate in the diet during gestation, lactation, and post-natally 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 intra-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 was used in this assessment.

9.2.2 Arsenic

For assessment of non-cancer risks from arsenic, IRIS (US EPA 2013) provides 0.3 µg/kg BW/day for a chronic oral TDI, while JECFA recommends TDI of 1 µg/kg BW/day for oral exposures.

Arsenic is the only metal in this report 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 has been identified as the primary carcinogenic form, while organic arsenic compounds have relatively low carcinogenic activity but a higher bioaccumulation potential (Roy and Saha 2002).

To account for the low proportion of inorganic arsenic in food, it was assumed that 10% of the total detected arsenic in the fish is inorganic based on the estimate from Slejkovec, Bajc, and Doganoc (2004). Based on a market basket survey with chicken breasts (with ribs baked with skin until done at 350º F), the proportion of inorganic to total arsenic in chicken was estimated to be 0.0104, or 1.04% (Schoof et al. 1999), which was used to estimate the concentration of inorganic arsenic in grouse. Similarly, the proportion of inorganic to total organic arsenic in beef (used as a surrogate for moose and snowshoe hare) baked 30 minutes at 350º F was estimated to be 0.0078, or less than 0.78% (Schoof et al. 1999).

Berries were not analyzed in the food market study (Schoof et al. 1999); however, a variety of fruits including apples, bananas, grapes, oranges, peaches, and watermelons were included in the study. The average inorganic to total arsenic proportion in fruits analyzed by Schoof et al. (1999) was calculated be 0.48. Therefore, for this assessment, it was assumed that 48% of the total arsenic concentration in berries was in the inorganic form.

9.2.3 Beryllium

US EPA's IRIS provides an oral TDI of 0.002 mg/kg BW/day based on a 10% change for small intestinal lesions increase at the 0.46 mg/kg BW/day benchmark dose 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. While there is uncertainty due to the lack of chronic oral studies establishing LOAELs and absence of other endpoints, it is thought that the safety factor is adequately protective (Toxicological Review of Beryllium and Compounds; US EPA 2013).

9.2.4 Cadmium

Health Canada (2010b) provides a PTDI of 1 µg/kg BW/day, which was used in this assessment. This PTDI is similar to JECFA's PTMI of 25 µg/kg BW/month (JECFA 2011), which accounts for the long half-life of cadmium in the body. The JECFA 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 (2011) and IRIS (US EPA 2013) provide a TDI of 1 µg/kg BW/day for oral exposures to cadmium based on recommendations by the JECFA (JECFA 1972b, 2005).

9.2.5 Chromium

Health Canada (2010b) provides a TDI of 0.001 mg/kg BW/day for total chromium. This value was based on water intake and was derived from multiplication of the maximum acceptable concentration (MAC) for total chromium of 0.05 mg/L by a water consumption rate of 1.5 L/day, and divided by the body weight of 70 kg. IRIS provides an RfD of 0.003 mg/kg BW/day (US EPA 2013), which was derived from a NOAEL of 2.5 mg/kg BW/day based on a one year chronic toxicity study with rats (MacKenzie et al. 1958). An uncertainty factor of 900 was applied to the NOAEL: 10 for interspecies extrapolation, 10 for interhuman variability, 3 as modifying factor, and 3 to address concerns from other studies (Zhang and Li 1987). The more conservative Health Canada TDI of 0.001 mg/kg BW/day was used in this assessment.

9.2.6 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 PTDI of 500 μg/kg BW. However, recommendations were made for further collection of information on copper with emphasis on epidemiological surveys to study the evidence of copper-induced ill-health. TDIs of 91 μg/kg BW/day and 141 μg/kg BW/day were used for toddlers and adults, respectively, in this report.

9.2.7 Lead

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

9.2.8 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. As data are not readily available on the mercury species present in the local vegetation and terrestrial animals, for moose, grouse, hare, and plant tissues, total mercury was compared to the Health Canada (2010b) inorganic mercury PTDI as a TRV.

For fish, mercury was assumed to be present 100% as methylmercury (Health Canada 2007). 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).

9.2.9 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 is based on NPAEL of 0.9 mg/kg/day and a LOAEL of 1.6 mg/kg/day for reproductive effects in rats, with an uncertainty factor of 30. Molybdenum TDI values of 23 and 28 μg/kg BW/day were used for toddlers and adults, respectively.

9.2.10 Nickel

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

9.2.11 Selenium

Selenium is an essential element and is required for human nutrition. Health Canada (2010b) provides an age- and body weight-adjusted tolerable upper limit for selenium of 6.2 to 5.7 μg/kg BW/day (toddlers and adults, respectively). This was based on a NOAEL in adults of 0.8 mg/kg/day in a cohort study by Yang and Zhou (1994) and a NOAEL in children of 0.007 mg/kg/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).

9.2.12 Silver

Health Canada does not provide a TRV value for silver. However, US EPA's IRIS provides an oral TDI of 0.005 mg/kg BW/day based on a LOAEL of 0.014 mg/kg BW/day from a study in humans (Gaul and Staud 1935). An uncertainty factor of 3 was applied to account for minimal effects in a subpopulation that has exhibited an increased propensity for the development of argyria. Argyria is the critical effect in humans ingesting silver, a medically benign but permanent and photo-sensitive bluish-gray discoloration of the skin. Silver compounds have been employed for medical uses for centuries.

9.2.13 Thallium

Thallium is a wide-spread heavy metal, often naturally co-occurring with sulphide materials processed for recovery of gold and copper, with high toxicity similar to effects caused by cadmium, lead, and mercury exposure. Thallium is readily assimilated by plants from soils, which can cause concern for human health. Thallium salts are easily absorbed by the skin, the intestinal tract, and through inhalation of dust (Peter and Viraraghavan 2005). Polyneuritic symptoms, sleep disorders, headache, fatigue, and psychological disorders were found to be the major health effects associated with increased thallium levels in urine and hair. Thallium accumulates in bones, the renal medulla, and the central nervous system (Peter and Viraraghavan 2005). It is not known what the effects are from ingesting low levels of thallium over a long time.

Health Canada (2011) provides a PTDI of 0.07 μg/kg BW/day for thallium. Health Canada does not provide a rationale for the derivation of this PTDI, but states that the PTDI is considered temporary as it was derived from an incomplete data set. The PTDI of 0.07 µg/kg BW/day for thallium was used for this assessment.

9.2.14 Tin

The sub-chronic oral TDI for tin was obtained from the Health Effects Assessment Summary Table (US EPA 1997a) and was based on a NOAEL in rats of 2,000 mg/kg for kidney lesions. It was calculated based on the concentration of stannous chloride given to the rats by correcting for differences in molecular weight and application of an uncertainty factor of 100, giving a TDI of 0.6 mg/kg BW/day (US EPA 1997a). ATSDR lists a similar oral TDI of 0.3 mg/kg BW/day for inorganic tin and tin compounds.

9.2.15 Vanadium

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

9.2.16 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 two to give a NOAEL of 25 mg/day, which is 420 µg/kg BW/day in a 60 kg person. Thus, the USL 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 USL, the maximum total intake for zinc is equivalent to 700 µg/kg BW/day.

10. Risk Characterization

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10. Risk Characterization

10.1 INTRODUCTION

Using the results of the exposure assessment and TRV assessment, human health risks from the consumption of country foods were quantified using exposure ratios (ERs). The recommended maximum weekly intake (RMWI) rates were then calculated for each country food evaluated. These RMWIs were compared to current weekly consumption rates of the country foods. In addition, the incremental lifetime cancer risk (ILCR) was determined for metals (i.e., arsenic) that may be associated with carcinogenic potential.

10.2 ESTIMATION OF NON-CARCINOGENIC RISK

Human health risk estimates were quantified using ERs, and were calculated as:

$$\textit{Exposure Ratio (ER)} = \frac{\textit{Estimated Daily Intake (EDI)}}{\textit{Tolerable Daily Intake (TDI)}}$$

For non-carcinogenic COPCs in country foods, Health Canada (2004a) suggests that an ER of less than 0.2 indicates that the exposure does not pose a significant health risk to human receptors. An ER value greater than 0.2 does not necessarily indicate that adverse health effects will occur since the TRVs are conservative and protect human health by including additional uncertainty factors; however, it does suggest that the potential risk to human health may require a more detailed evaluation.

Table 10.2-1 presents the ERs based on the predicted metal concentrations in wildlife and measured fish and berry metal concentrations. Calculated ERs for snowshoe hare, berries, and Dolly Varden/bull trout were all below 0.2. Thus, it is expected that consumption of these three country foods at the rates used in the calculations do not pose a risk to human health for any human life stages for any of the metals evaluated.

Table 10.2-1. Human Exposure Ratios Based on Predicted and Measured Tissue Concentrations in Country Foods

	Exposure Ratio for Adult Receptor				
COPC	**Moose**	**Grouse**	**Snowshoe Hare**	**Berries**	**Dolly Varden/Bull Trout**
Aluminum	2.01×10^{-02}	1.71×10^{-01}	2.18×10^{-05}	7.98×10^{-03}	3.19×10^{-03}
Arsenic[a]	4.51×10^{-03}	4.27×10^{-02}	5.10×10^{-06}	1.36×10^{-02}	1.44×10^{-03}
Beryllium	1.33×10^{-03}	1.28×10^{-03}	8.58×10^{-07}	4.31×10^{-02}	nd
Cadmium	2.20×10^{-03}	6.04×10^{-04}	1.35×10^{-06}	1.32×10^{-02}	6.57×10^{-04}
Chromium	1.47×10^{-01}	9.06×10^{-02}	1.66×10^{-04}	8.51×10^{-02}	3.44×10^{-02}
Copper	1.50×10^{-02}	7.76×10^{-03}	1.36×10^{-05}	1.16×10^{-02}	6.99×10^{-04}
Lead	1.70×10^{-03}	5.35×10^{-02}	1.62×10^{-06}	4.73×10^{-03}	4.32×10^{-03}
Mercury	4.39×10^{-01}	3.69×10^{-04}	3.50×10^{-04}	3.92×10^{-03}	7.96×10^{-03}
Molybdenum	5.12×10^{-07}	1.24×10^{-06}	5.18×10^{-10}	7.23×10^{-06}	2.32×10^{-08}
Nickel	1.26×10^{-02}	1.26×10^{-05}	9.63×10^{-06}	3.68×10^{-02}	4.48×10^{-04}
Selenium	3.42×10^{-03}	5.23×10^{-03}	2.27×10^{-06}	2.98×10^{-02}	2.07×10^{-02}
Silver	3.57×10^{-04}	5.06×10^{-03}	4.53×10^{-07}	nd	nd

(continued)

Table 10.2-1. Human Exposure Ratios Based on Predicted and Measured Tissue Concentrations in Country Foods (completed)

COPC	Exposure Ratio for Adult Receptor				
COPC	Moose	Grouse	Snowshoe Hare	Berries	Dolly Varden/Bull Trout
Thallium	2.66×10^{-01}	4.09×10^{-02}	2.18×10^{-04}	1.23×10^{-01}	2.47×10^{-02}
Tin	5.20×10^{-04}	2.88×10^{-05}	3.90×10^{-07}	5.17×10^{-04}	1.11×10^{-05}
Vanadium	1.35×10^{-02}	2.70×10^{-05}	1.50×10^{-05}	9.45×10^{-03}	1.53×10^{-03}
Zinc	1.02×10^{-04}	1.65×10^{-05}	6.34×10^{-08}	5.62×10^{-03}	1.90×10^{-03}
	Exposure Ratio for Toddler Receptor				
COPC	Moose	Grouse	Snowshoe Hare	Berries	Dolly Varden/Bull Trout
Aluminum	3.70×10^{-02}	3.14×10^{-01}	4.02×10^{-05}	1.47×10^{-02}	5.88×10^{-03}
Arsenic[a]	8.31×10^{-03}	7.87×10^{-02}	9.40×10^{-06}	2.51×10^{-02}	2.66×10^{-03}
Beryllium	2.46×10^{-03}	2.36×10^{-03}	1.58×10^{-06}	7.93×10^{-02}	nd
Cadmium	4.06×10^{-03}	1.11×10^{-03}	2.48×10^{-06}	2.44×10^{-02}	1.21×10^{-03}
Chromium	2.71×10^{-01}	1.67×10^{-01}	3.05×10^{-04}	1.57×10^{-01}	6.34×10^{-02}
Copper	2.76×10^{-02}	1.43×10^{-02}	2.51×10^{-05}	2.13×10^{-02}	1.29×10^{-03}
Lead	3.13×10^{-03}	9.86×10^{-02}	2.99×10^{-06}	8.71×10^{-03}	6.64×10^{-04}
Mercury	8.08×10^{-01}	6.79×10^{-04}	6.45×10^{-04}	7.21×10^{-03}	3.00×10^{-02}
Molybdenum	1.15×10^{-06}	2.78×10^{-06}	1.16×10^{-09}	1.62×10^{-05}	5.20×10^{-08}
Nickel	2.33×10^{-02}	2.32×10^{-05}	1.77×10^{-05}	6.78×10^{-02}	8.25×10^{-04}
Selenium	5.79×10^{-03}	8.87×10^{-03}	3.85×10^{-06}	5.06×10^{-02}	3.51×10^{-02}
Silver	6.58×10^{-04}	9.32×10^{-03}	8.35×10^{-07}	nd	nd
Thallium	4.90×10^{-01}	7.53×10^{-02}	4.01×10^{-04}	2.27×10^{-01}	4.56×10^{-02}
Tin	9.59×10^{-04}	5.31×10^{-05}	7.19×10^{-07}	9.53×10^{-04}	2.04×10^{-05}
Vanadium	2.48×10^{-02}	4.98×10^{-05}	2.77×10^{-05}	1.74×10^{-02}	2.82×10^{-03}
Zinc	1.89×10^{-04}	3.04×10^{-05}	1.17×10^{-07}	1.04×10^{-02}	3.49×10^{-03}

nd = not determined
COPC = contaminants of potential concern
Shaded numbers denote country food with an exposure ratio larger than 2×10^{-01} (i.e., > 0.2) for a particular COPC.
[a] *Arsenic exposure ratios are based on inorganic arsenic concentrations.*

For both adults and toddlers, the ER values for COPCs in moose were below 0.2 for all metals of concern except mercury (adult ER = 0.44; toddler ER = 0.81) and thallium (adult ER = 0.27; toddler ER = 0.49). In addition, in toddlers only, the ERs for grouse consumption associated with aluminum (ER = 0.31), for moose consumption associated with chromium (ER = 0.27), and for berries consumption associated with thallium (ER = 0.23) were slightly above 0.2.

10.3 ESTIMATION OF CANCER RISKS

Of the metals evaluated, only arsenic is considered carcinogenic through ingestion. Carcinogenic risks were calculated as ILCR estimates according to the following formula (Health Canada 2010a):

$$ILCR = Estimated\ Lifetime\ Daily\ Exposure \left(\frac{mg}{\mathrm{kg}_{bw} day}\right) \times Oral\ Cancer\ Slope\ Factor \left(\frac{mg}{\mathrm{kg}_{bw} day}\right)^{-1}$$

The following equation was used to calculate the estimated lifetime daily exposure (ELDE) according to the following formula (Health Canada 2010a):

$$ELDE_{country\ food} = \frac{IR \times F_s \times C_{country\ food} \times P_{as} \times YE}{BW \times LE}$$

where:

$ELDE_{country\ food}$ = estimated lifetime intake of country food (mg COPC/kg BW/day)
IR = ingestion rate (kg/day)
F_s = fraction of year consuming country food (unitless)
C_{food} = concentration of COPCs in food (mg/kg)
P_{as} = proportion of inorganic arsenic relative to total arsenic concentration
YE = years exposed (yr)
BW = body weight (kg)
LE = life expectancy (yr)

For the ELDE, measured or predicted arsenic concentrations in tissue were used in the exposure calculations and results are presented in Table 10.3-1. The oral slope factor for arsenic cancer risk is 1.8 per (mg/kg BW/day)$^{-1}$ (Health Canada 2010b). Appendix F provides a sample calculation for the estimated lifetime daily exposure of arsenic for an adult consuming snowshoe hare. An ILCR estimate that is less than 1×10^{-05} is normally considered acceptable (Health Canada 2010a).

Table 10.3-1. Estimated Lifetime Daily Exposure and Incremental Lifetime Cancer Risk for Adult Human Receptors Exposed to Arsenic in Country Foods

Country Food	ELDE mg/kg/day	ILCR unitless
Moose	1.35×10^{-06}	2.44×10^{-06}
Grouse	1.28×10^{-05}	2.31×10^{-05}
Snowshoe hare	1.53×10^{-09}	2.75×10^{-09}
Berries	4.51×10^{-06}	8.12×10^{-06}
Dolly Varden/bull trout	4.33×10^{-07}	7.79×10^{-07}

Shaded numbers indicate elevated incremental lifetime cancer risk.
ILCR = incremental lifetime cancer risk
ELDE = estimated lifetime daily exposure
An ILCR estimate less than 1×10^{-05} is normally considered acceptable (Health Canada 2010a)

The results of the ILCRs from exposure to arsenic in country foods are presented in Table 10.3-1. The calculated ILCR for arsenic from moose, snowshoe hare, berries, and Dolly Varden/bull trout were less than 1×10^{-05} and can be considered safe for consumption at the assumed consumption rates. However, the consumption rates for grouse used in this assessment were associated with a higher ILCR than is considered acceptable (2.31×10^{-05}).

In a screening level risk assessment, such as this country foods baseline assessment report, it is common to make a number of very conservative assumptions during the assessment process which will tend to overestimate the actual risk to human health. If no unacceptable risks are identified using this conservative approach, then it is very unlikely that human health will be affected by consumption of country foods at the frequencies and quantities used in the assessment.

However, when unacceptable risks are identified, such as the identification of elevated ILCR associated with grouse consumption as has occurred here, the data and assumptions used to estimate the risks should be examined more closely. This reassessment is important, since overestimation of risk as a result of applying conservative assumptions can lead to needless concern in human consumers of country foods. People may choose to avoid eating country foods due to concerns about potential health effects due to COPCs that may be present, which can have social, cultural, or economic impacts.

In this country foods assessment, since the calculated ILCR exceeds the acceptable ILCR of 1×10^{-05}, some of the data and assumptions were reconsidered to ensure that a more accurate estimate of the risk to human consumers is presented and to avoid creating unnecessary concern about country food quality.

10.3.1 Effects of Spatial Variation in Arsenic Concentrations within the Country Foods Local Study Area on the Incremental Lifetime Cancer Risk

Brucejack Lake is located on a high plateau above the treeline at an elevation of 1,400 masl and is ice-bound for about eight months of the year (Rescan 2013c).The lake currently has very low potential for accessibility due to the lack roads to the area. Fish are not present in Brucejack Lake or the tributaries of the lake (Rescan 2013b). Little wildlife was observed at such elevations (Rescan 2013i). For example, no moose have been observed in the areas around Brucejack Lake, or in the Mine Site study area (Rescan 2013i). Spruce grouse (Williamson et al. 2008), sooty grouse (BirdLife International 2012), and ruffed grouse (Campbell et al. 1990), all of which have been identified as potentially occurring bird species in the country foods study area (Rescan 2013i), are generally found in forested regions only up to the treeline. Although there are no physical barriers to prevent wildlife from grazing or residing in the Mine Site study area, habitat limitations or quality likely restricts or reduces their presence in this area.

Based on the above information, it is reasonable to assume that moose and grouse would be unlikely to spend substantial amounts of time within the Mine Site study area portion of the country foods study area. Therefore, their potential to take in arsenic from environmental media (soil, water, and vegetation) would most likely occur in the remaining areas of the country foods study area.

Concentrations of arsenic in the environmental media of the Mine Site study area are higher than the other two areas (Access Road and Transmission Line South Option study areas). Table 10.3-2 presents the differences in arsenic concentrations in the various environmental media between the original dataset including the Mine Site study area and the re-calculated dataset excluding the Mine Site study area.

Table 10.3-2. Comparison of Arsenic Concentrations in Environmental Media Including or Excluding Data from the Mine Site study area

Environmental Media	95% UCLM Arsenic Concentration, Including Data from the Mine Site study area	95% ULCM Arsenic Concentration, Excluding Data from the Mine Site study area
Soil	151 mg/kg dry weight	26.3 mg/kg dry weight
Vegetation	0.623 mg/kg wet weight	0.145 mg/kg wet weight

ULCM = upper confidence limit of the mean

Arsenic concentrations in all soil samples collected within the country foods study area ranged from 5.28 to 883 mg/kg dry weight (dw), with a 95% UCLM concentration of 151 mg/kg dw (Table 10.3-2). Arsenic in the soil samples from the Mine Site study area had a 95% UCLM concentration of 258 mg/kg dw, which was higher than the arsenic concentrations in soil samples collected from the Access Road and Transmission Line South Option study areas (95% UCLM concentration of 26.3 mg/kg dw; excluding the Mine Site study area).

Arsenic concentrations in all vegetation samples collected within the country foods study area ranged from 0.0007 to 7.31 mg/kg wet weight (ww), with a 95% UCLM concentration of 0.623 mg/kg ww (Table 10.3-2). Arsenic concentrations in the vegetation samples collected within the Mine Site study area ranged from 0.00070 mg/kg ww to 7.31 mg/kg ww, with a 95% UCLM concentration of 1.57 mg/kg ww. This was higher than arsenic concentrations in vegetation collected within the Access Road and Transmission Line South Option study areas (range of 0.005 to 1.41 mg/kg ww with a 95% UCLM concentration of 0.145 mg/kg ww; excluding the Mine Site study area).

Considering the higher arsenic concentrations in the soil compared to vegetation or water, even with low soil ingestion rates of 0.15 kg/day for moose and 0.07 kg/day for grouse, the soil ingestion component of the food chain model for estimating tissue metal residues is the driving force in the ILCR calculations for arsenic for moose and grouse.

Based on the preceding information and rationale in this section, the ILCRs presented in Table 10.3-1 are most likely an overestimation of the true risk since these ILCRs were calculated based on metal concentrations measured in environmental media samples from all of the country foods study area, including those from the Mine Site study area. Since moose and grouse are not likely to graze or reside in the Mine Site study area portion of the country foods study area, where arsenic concentrations are highest, re-calculation of ILCRs after the exclusion of the Mine Site study area data provides a more realistic measure of potential risk associated with human consumption of these animals from within the country foods study area.

Based on the 95% UCLMs for arsenic in the environmental media sampled from within the Access Road and Transmission Line South Option study areas, the food chain model was re-run to estimate total arsenic tissue residues (which were then converted to inorganic arsenic concentrations, see Section 9.2.2) and ILCRs were subsequently recalculated for grouse consumption. The previous estimate of inorganic arsenic concentration in grouse tissue was 0.0870 mg/kg, while the recalculated estimate of inorganic arsenic concentrations for grouse tissue was 0.0161 mg/kg.

The recalculated ILCR due to consumption of grouse was 4.02×10^{-06} (Table 10.3-3). Thus, based on these calculations, the ILCR for arsenic due to consumption of grouse is associated with an acceptable risk level.

Table 10.3-3. Recalculated Lifetime Daily Exposure and Incremental Lifetime Cancer Risk for Adult Human Receptors Exposed to Arsenic in Country Foods after Excluding Mine Site Metal Concentrations

Country Food	ELDE mg/kg/day	ILCR unitless
Moose	2.58×10^{-07}	4.65×10^{-07}
Grouse	2.23×10^{-06}	4.02×10^{-06}
Snowshoe hare	2.77×10^{-10}	4.99×10^{-10}
Berries	4.06×10^{-06}	7.31×10^{-06}
Dolly Varden/bull trout	4.33×10^{-07}	7.79×10^{-07}

Shaded numbers indicate elevated incremental lifetime cancer risk.
ILCR = incremental lifetime cancer risk
ELDE = estimated lifetime daily exposure
An ILCR estimate less than 1 x 10^{-05} *is normally considered acceptable (Health Canada 2010a)*

10.4 RECOMMENDED MAXIMUM WEEKLY INTAKES

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

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

where:

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

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 G). By using the lowest RMWI for each food type, it is protective for all metals in that particular food. Table 10.4-1 presents the RMWIs that would be protective against potential effects to human health due to naturally occurring metals present in the foods. RMWIs have been also converted to the recommended maximum number of servings per week of moose, grouse, snowshoe hare, berries, and Dolly Varden/bull trout by dividing the RMWI by the serving size (Jin 2006).

Table 10.4-1. Recommended Maximum Weekly Intake and Number of Servings of Country Food

Human Receptor	Country Food	Lowest Metal RMWI (kg/week)	Serving Size (kg/serving)	Recommended Number of Servings (# Servings/Week)	Current Number of Servings (# Servings/Week[1])
Adult	Moose	3.39	0.213	15.9	6.98
	Grouse	0.403	0.299	1.35	0.230
	Hare	229	0.348	657	0.230
	Berries	6.81	0.280	24.3	2.99
	Dolly Varden/Bull Trout	1.87	0.279	6.69	0.230
Toddler	Moose	0.791	0.0916	8.64	6.98
	Grouse	0.0941	0.129	0.732	0.230
	Hare	53.4	0.150	357	0.230
	Berries	1.59	0.120	13.2	2.99
	Dolly Varden/Bull Trout	0.436	0.120	3.63	0.230

RMWI = recommended maximum weekly intake, n/a = not applicable
[1] based on annual averages (Jin 2006)

As noted in Section 10.3-1 calculations that include environmental samples from the Mine Site study area are most likely an overestimation of the true risk and are therefore considered to be very conservative. The recommended number of weekly servings is greater than the current weekly number of servings of moose, snowshoe hare, grouse, berries, and Dolly Varden/bull trout used in this assessment (Table 10.4-1), even when including data from the Mine Site study area in the calculations. Thus, country foods harvesters are not expected to experience health risks related to country food consumption based on consumption rates and frequencies used in this assessment.

11. Uncertainty Analysis

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11. Uncertainty Analysis

11.1 INTRODUCTION

The process of evaluating human health risks from exposure to environmental media involves multiple steps, each containing inherent uncertainties that ultimately affect the final risk estimates. These uncertainties exist in numerous areas, including the collection of samples, laboratory analysis, estimation of potential exposures, and derivation of toxicity reference values, resulting in either an over- or under-estimation of risk. However, for the present study, where uncertainties existed, a conservative approach was taken to overestimate rather than underestimate potential risks.

Some of the uncertainties have been mentioned in the preceding report sections. The following uncertainty analysis is a qualitative discussion of the key sources of uncertainty in this study. There may be sources of uncertainty other than those evaluated here; however, their effect on the calculation of ILCRs and RMWIs are considered to be less significant.

11.2 CONTAMINANTS OF POTENTIAL CONCERN

The COPCs selected for this assessment were metals, since the proposed Project involves development of a metal mine. Metals naturally occur in environmental media (i.e., soil, water, and plant and animal tissue) and have been monitored during baseline studies to support Project planning and processes. By screening measured baseline metal concentrations against environmental quality guidelines it is likely that all relevant metal COPCs have been selected for inclusion in the country foods baseline assessment.

However, there exists a possibility that other COPCs (e.g., other metals, organic chemicals, etc.) could be associated with Project activities in the future, but do not occur or were not measured under baseline conditions.

11.3 TISSUE CONCENTRATIONS

11.3.1 Wildlife Species

Concentrations of metals in the tissue of moose, snowshoe hare, and grouse were predicted using a food chain model. As with all modelled data, the results are highly dependent on the accuracy of literature-based input parameters and the quality of the model itself. Standard methodologies for application of models have been used and clearly described throughout this report.

The main uncertainty in the food chain model was in the selection of biotransfer factors (BTFs). 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 or snowshoe hare. Similarly, values for the grouse were based on available avian species information (chickens). Notwithstanding, this is the accepted method to model the uptake of COPCs into animals when empirical data are not available or samples sizes are too small to make conclusions about population tissue concentrations.

The moose, snowshoe hare, and grouse ingestion rates that were used for food, soil, and water were based on guidance for estimating wildlife exposure characteristics provided by the US EPA (1993). Wherever possible, conservative assumptions have been made to ensure that potential risks are not underestimated. For example, most soil ingestion by moose occurs incidentally from grazing on grasses or forging for vegetation on the ground. Moose and other ungulates occasionally intentionally 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. The food chain model assumed that moose would consume soil at the combined intentional and incidental ingestion rate. The same approach was used for grouse because they may consume small rocky material to aid in physically breaking down food in their gizzards and crops. Overall, it is anticipated that the soil and plant ingestion rates by moose, snowshoe hare, and grouse have been overestimated, which would result in conservatism in the risk estimates.

The exposure time that moose, grouse, and snowshoe hare would spend within the country foods study area was conservatively assumed to be 100%. Non-migratory moose have a mean multiannual home range of 42 km^2 (Demarchi 2000), while migratory moose has much wider home range. It is unlikely that moose will spend all of their time within the country foods study area. Therefore, the exposure time factor used in the wildlife model is very conservative for moose. Snowshoe hare and grouse have much smaller home ranges and their home range could plausibly be located entirely within the country foods study area. Therefore, the exposure time was assumed to be 100%. This assumption results in human health risks being overestimated rather than underestimated, particularly if residence times are less than 100%.

Other uncertainties associated with the predicted animal tissue concentrations include the assumption that the diet of moose, snowshoe hare, and grouse include solely the plants and berries that were collected in the field during baseline studies. 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. However, the model is expected to overestimate tissue residues (Golder 1995), which helps to compensate for any uncertainties.

11.3.2 Aquatic Species

Dolly Varden/bull trout were collected from Wildfire Creek in 2012 and were analyzed for tissue metal residues. While the dataset available for Dolly Varden/bull trout tissue metal residues (n = 11) is considered small and fish were sampled from a single source, the data still provides an indication of the metal concentrations in these organisms in a portion of the country foods study area. Additional data from other locations within the country foods study area may provide a more accurate estimate of metal concentrations in Dolly Varden/bull trout populations, especially in terms of the potential for spatial variability in tissue concentrations.

11.3.3 Plant Species

A total number of 64 plant samples were collected from the country foods study area for analysis of tissue metal concentrations. It is likely that the number of species and samples are a good representation of the plant species consumed by wildlife. There is a high degree of variation in metal concentrations between the plant species, likely due to species-specific physiological characteristics. Therefore, it is important to collect different plant species and not rely on surrogates.

11.3.4 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) procedures were followed during the sampling of the soil, water, vegetation, and fish for metal analysis. All persons collecting the water, soil, sediment, and tissue samples were trained on appropriate sampling techniques. This minimized the potential for cross-contamination and ensured that the sample sizes were adequate for chemical analyses.

Additional details on the QA/QC of the environmental media sampling are presented in the respective soil, vegetation, freshwater, and fish baseline reports (Rescan 2013b, 2013e, 2013c, 2013f).

All samples were analyzed by ALS Environmental in Burnaby, BC. ALS is certified by the Canadian Association of Environmental Analytical Laboratories. Chain of custody forms were completed and transported with all water, soil, and tissue samples that were sent to ALS.

11.4 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 country foods study area. This is an overestimate, given the vast area available for harvesting and the general inaccessibility of portions of the country foods study area under baseline conditions. The overestimation provides conservatism in the risk predictions.

11.5 CONSUMPTION AMOUNTS AND FREQUENCY

Skii km Lax Ha and Tahltan Nation territories overlap with the country foods study area. Skii km Lax Ha country foods consumption frequency data was obtained from a written survey-style country foods consumption interview conducted by Rescan (Appendix A). Consumption amount and frequency data was also based on values provided for the Tahltan Nation (Jin 2006) since the country foods study area slightly overlaps with the southern part of the Tahltan territory. The highest consumption frequency from either Skii km Lax Ha or Tahltan Nation was selected to provide a conservative risk estimate, protective of both consumer groups.

In most cases except for moose, Skii km Lax Ha reported a higher consumption frequency for the selected country foods than the Tahltan Nation. For moose in particular, the high frequency and amounts of consumption reported in Jin (2006) for the Tahltan are likely overestimated rather than underestimated, since it estimated that consumption of moose occurs almost on a daily basis.

The Skii km Lax Ha Country Foods Questionnaire results for moose and berries were provided in a quantitative manner (Appendix A; moose and blueberries were reported to be consumed two to three times a week). The assessment assumed the higher end of the range of the consumption rate in these instances. However, grouse, snowshoe hare, and Dolly Varden were indicated to be eaten "occasionally" during the past year. Based on personal communications with the Dr. Peter Evans who interviewed Chief Darlene Simpson of Skii km Lax Ha (P. Evans, pers. comm.), "occasional" consumption is indicative of consumption frequency of less than two times a month. In these instances, it was assumed that country foods with "occasional" consumption frequency were consumed once a month throughout the year. However, there is uncertainty in this assumption since the true frequency is not known and may vary between different foods.

The Skii km Lax Ha Country Foods Questionnaire results were assumed to be representative of consumption habits and frequency of all Skii km Lax Ha members. There are uncertainties associated with this assumption since country foods consumption habits of individual members of Skii km Lax Ha may differ.

Consumption amounts and frequencies for toddlers also carry some uncertainty. As a conservative approach, it was assumed that toddlers ranging from six months to four years old consumed food at a rate of 43% of an adult consumption frequency based on recommendations made by Richardson (1997). It is unlikely that toddlers consume roughly half the amount of food that an adult would. It is probable that actual exposure to COPCs from ingestion of country foods is lower for toddlers.

11.6 TOXICITY REFERENCE VALUES

There is uncertainty associated with estimating TRVs by extrapolating potential effects on humans from animal studies in the laboratory. For human health risk assessments, it is standard practice to assume that people are more sensitive to the toxic effects of a substance than laboratory animals. Therefore, the toxicity benchmarks for human health are set at much lower levels than the animal benchmarks (typically 100 to 1,000 times lower due to the application of safety factors). This large margin ensures that doses less than the TRVs 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), synergism (overall effect is greater than the sum of the individual effects), or potentiation (presence of one chemical results in toxicity of another chemical that otherwise would have been safe). Many of these interactions are poorly understood or remain unknown by modern science. Furthermore, in natural systems numerous physical variables (e.g., media temperature, pH, salinity, hardness, etc.) can accelerate or impede these chemical interactions. Because of these environmental variables, as well as poorly understood interactions among different compounds, assessments were only conducted for the individuals COPC levels and not for overall health effects.

11.7 DEFINITION OF HEALTH

This country foods assessment is a science-based approach recommended by Health Canada to protect human receptors from adverse health effects caused by exposure to the selected COPCs (metals). Community health and well-being is being addressed as part of the *Socio-economic Baseline* Report for the Project (Rescan 2013d). However, it is recognized that health is defined by more than just physical well-being, as social, cultural, nutritional, and economic factors can also play a role in a person's overall health status.

12. Conclusions

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12. Conclusions

This country foods baseline assessment integrated the results of the environmental media baseline data, human receptor characteristics, and regulatory-based TRVs. The potential for adverse human health effects as a result of consumption of five country foods (moose, snowshoe hare, grouse, berries, and Dolly Varden/bull trout) was assessed. The country foods baseline assessment methodology was based on Health Canada's guidelines for assessing country foods (Health Canada 2004).

Rather than the mean concentrations, the 95% UCLM of metal concentrations were used to estimate the tissue metal concentrations in all country foods, RMWIs, and ILCRs. The duration for which the animals were assumed to be present within the country foods study area, consumption frequencies of country foods, and portion size of country foods consumed were conservative. In addition, it was assumed that all country foods consumed were collected from within the country foods study area. It is likely that the potential risk to human health due to country foods consumption from within the country foods study area is likely overestimated.

Even using many conservative assumptions, this assessment found no unacceptable risks to human health from metal COPCs due to consumption of moose, snowshoe hare, grouse, berries, and Dolly Varden/bull trout under baseline conditions at the consumption rates and frequencies used in the assessment.

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Appendix A

Skii km Lax Ha Country Foods Consumption Questionnaire

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Appendix A. Skii km Lax Ha Country Foods Consumption Questionnaire

1. INTRODUCTION

The Skii km Lax Ha Country Foods Questionnaire was prepared for Pretium Resources Inc. (Pritivm) for the Brucejack Gold Mine Project (the Project) for use by Skii km Lax Ha First Nations. 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 quality of country foods is directly related to the quality of the surrounding environmental media (e.g., soil, water, and vegetation).

Health Canada (2010) strongly recommends gathering site-specific country foods consumption data rather than using Richardson's generic food ingestion rates (Richardson 1997). The country foods study area and all of the major components of the proposed Project is within the Skii km Lax Ha Traditional Territory (see Figures 5.1-1 and 7.2-2 or Rescan 2013a). For the Skii km Lax Ha, hunting, trapping, fishing, and plant, berry, and mushroom harvesting are important activities based on cultural practices and financial necessities (see Figure 7.2-5 or Rescan 2013b). Therefore, country foods consumption data from the Skii km Lax Ha would be the most relevant and informative data for assessing the potential risk proposed by country foods consumed from the country foods study area.

2. METHODS

Typically in country foods studies, one species is selected from each of the following groups of foods: terrestrial wildlife (a large mammal and a small mammal), a bird, fish, and a plant. A species that represents the highest consumption level, and therefore results in the highest potential exposure to contaminants of potential concerns (COPCs), is selected from within each of these groups. Theoretically, if foods that represent the highest rate of exposure are determined to be safe for consumption, then all other foods within the group would also be considered safe for consumption. The different groups are selected because the relative exposure of organisms in each group to the environmental media varies with specific habitat and foraging behaviors.

A country foods questionnaire was prepared including questions about the consumption frequency of foods that may be gathered and consumed from the country foods study area from each of the main groups of country foods. A map indicating the country foods study area (Figure 5.1-1) and the Skii km Lax Ha Country Foods Questionnaire was sent by fax to Chief Darlene Simson of Skii km Lax Ha on May 21, 2012. Dr. Peter Evans, who assists Skii km Lax Ha with matters relating to traditional land use and traditional ecological knowledge (Peter Evans, per. comm.), interviewed Chief Darlene Simpson using the Skii km Lax Ha Country Foods Consumption Questionnaire. Dr. Evans returned the completed questionnaire by email on May 27, 2012. The following sections provide the results of this interview.

3. RESULTS

It was assumed that 100% of the indicated harvests in the questionnaire were obtained from the country foods study area. In addition, it was assumed that the answers provided in the questionnaire were representative of the consumption habits of all Skii km Lax Ha members.

Some consumption frequencies provided in the questionnaire were in qualitative terms such as "occasional", "rarely", and "very rarely". "Occasional" consumption is indicative of consumption frequency of less than two to three times a month (P. Evans, pers. comm.). Therefore, for country foods consumed on an "occasional" basis, consumption frequency of once a month was used. Country foods consumed "rarely" and "very rarely" were assumed to be consumed six times a year and once a year, respectively. Beaver and hoary marmot occasional consumption was clarified to be occasional hunting for skin use rather than consumption (See 3.1 Terrestrial Wildlife, P. Evans, pers. comm.).

3.1 Terrestrial Wildlife

Do you hunt/trap animals in the Study area? Yes ☒ No ☐

Animal Name	What part of the animal is eaten (blubber, muscle, everything)?	How often did you eat this animal after the last hunt (i.e. once p/w, once p/m)?
Moose	Everything – meat, marrow, tripe, heart, kidneys…	2-3 p/w (a staple, along with salmon)
Snowshoe Hare	Meat	Occasional
Black Bear	Meat, cooked and dried.	2-3/m in spring only [sausage in fall and winter]
Deer	Meat	Occasional
Grizzly Bear	Meat	Very rarely
Mountain Goat	Meat	Occasional
Beaver	Used for skins	Occasional
Hoary Marmot	Used for skins	Occasional
Other:		

This table is copied directly from the completed questionnaire received from Dr. Evans received on May 27, 2012.

3.2 Birds

Do you hunt birds in the Study area? Yes ☒ No ☐

Bird Name	What part of the fish is eaten?	How often did you eat this bird in the past year (i.e. once p/w, once p/m)?
Grouse	Meat	Occasional
Ducks	Meat	2-3/m
Ptarmigan	Meat	Occasional
Canada Goose	Meat	Occasional
Common Loon	-	-
Mallard	Meat	Very rare
Swans	-	-
Other:		

This table is copied directly from the completed questionnaire received from Dr. Evans received on May 27, 2012.

3.3 Plants

Do you collect plants and berries in the Study area? Yes ☒ No ☐

Plant Name	What part of the plant is eaten (berries, roots, leaves)?	How often did you eat this plant in the past year (i.e. once p/w, once p/m)?
Alaskan Blueberry	Berries	Feasting and daily use 2-3/w
Black Gooseberry	-	-
Black Huckleberry	-	-
Bog Cranberry	Berries, Juice	Occasional
Bunchberry	-	-
Cow Parsnip	-	-
Crowberry	-	-
Devil's Club	Inner bark	Occasional (Springtime) 4-5/w
Dwarf Blueberry	Berries	2-3/w
Grouse Berry	-	-
Highbush Cranberry	-	-
Mountain Ash	-	-
Northern Blackcurrent	-	-
Oval-leaved Blueberry	(See blueberries above)	(See blueberries above)
Salmonberry	Berries	Occasional
Sub-alpine Fir	-	-
Trailing Black Currant	-	-
Yarrow	-	-
Others: Dandelions	Leaves	Occasional
Others: Soapberries	Berries	1/d
Others: Fiddleheads	Heads	Occasional
Wild Onion Root	Root	Rare

This table is copied directly from the completed questionnaire received from Dr. Evans received on May 27, 2012.

3.4 Fish

Do you fish in the Study area? Yes ☒ No ☐

Fish Name	What part of the fish is eaten?	How often did you eat this fish in the past year (i.e. once p/w, once p/m)?
Dolly Varden	Meat	Occasional
Bull Trout	-	-
Chinook Salmon	Meat, head, bones	2-3/w – all day long
Sockeye	Meat, head, bones	2-3/w – all day long
Coho Salmon	Meat	Occasional
Cutthroat Trout	-	-
Mountain Whitefish	Meat	Very rare
Rainbow Trout	Meat	2-3/m
Steelhead	Meat	Occasional
Other: Oolichan	grease	2-3/w with other dried meat.

This table is copied directly from the completed questionnaire received from Dr. Evans received on May 27, 2012.

4. CONCLUSIONS

Based on the information provided by Chief Darlene Simpson, Skii km Lax Ha harvest small and large terrestrial mammals, birds, plants, and fish from the country foods study area. Among terrestrial wildlife, moose is the large mammal that is consumed most frequently in comparison to the black bear, deer, grizzly bear, and mountain goat. Among small mammals, snowshoe hare is consumed occasionally. Although beaver and hoary marmot are hunted occasionally as well, these animals are used for their skins rather than consumption.

Among avian species, ducks are consumed most frequently (two to three times a month) while grouse, ptarmigan, and Canada goose are consumed occasionally. Mallards are consumed very rarely.

Chinook and sockeye salmon and oolichan are fish consumed most often (two to three times a week), rainbow trout 2-3 times a month, while Dolly Varden, coho salmon, and steelhead are fished occasionally. Mountain whitefish are consumed very rarely.

A variety of berries and plants are harvested by Skii km Lax Ha. The most popular berries are soapberries, which were reported to be consumed once a day. Blueberries are also among popular berries (Alaskan blueberries, oval-leaved blueberries, and Dwarf blueberries) and are consumed two to three times a week. Among non-berry plants, Devil's Club is consumed four to five times a week during the spring and dandelions and fiddleheads are consumed occasionally.

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Appendix B

Summary of Measured Metal Concentration in Physical Environmental Media

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Appendix B1. Summary of Metal Concentrations in Soil from 2008 to 2012

Metals	Minimum	Mean	Maximum	95% UCLM
Aluminum	8370	19783	37900	21778
Antimony	0.32	4.05	17	5.44
Arsenic	5.28	96.1	883	151
Barium	43.3	149	1110	209
Beryllium	0.1	0.465	1.57	0.559
Bismuth	0.1	2.68	10	4.01
Cadmium	0.078	0.339	1.30	0.430
Calcium	156	3370	30100	5086
Chromium	1	36.4	118	46.3
Cobalt	1	14	123	20.3
Copper	9.78	136	1060	220
Iron	28600	53600	373000	71965
Lead	7.12	19.3	69.0	24.4
Lithium	1	18.9	61.4	22.4
Magnesium	363	6625	15900	7660
Manganese	84.2	829	2400	994
Mercury	0.0197	0.215	2.72	0.364
Molybdenum	0.85	10.7	154	19.6
Nickel	1.49	24.6	69.0	30.8
Phosphorus	463	1074	3120	1239
Potassium	100	766	1820	888
Selenium	0.1	1.72	10.8	2.42
Silver	0.05	0.992	4.20	1.30
Sodium	50	112	1380	184
Strontium	2.05	27.7	270	42.3
Thallium	0.069	0.281	1.25	0.355
Tin	1	1.68	6.80	2.10
Titanium	46.1	457	1670	599
Uranium	0.108	0.597	2.69	0.800
Vanadium	5.85	69.9	178	82.9
Zinc	13.7	74.5	208	85.6

All values expressed in mg/kg dry weight

Sample size (n) = 31 except for uranium (n = 23)

UCLM = Upper Confidence Limit of the Mean

Appendix B2. Summary of Metal Concentrations in Surface Water from 2007 to 2012

Metals	Minimum	Mean	Maximum	Sample Size (n)	95% UCLM
Aluminum	0.0071	1.30	10.6	169	1.57
Antimony	0.00005	0.000611	0.00405	169	0.000697
Arsenic	0.00005	0.00175	0.0124	168	0.00206
Barium	0.009	0.0505	0.251	169	0.056
Beryllium	0.00005	0.000206	0.00025	169	0.000216
Bismuth	0.00025	0.00025	0.00025	169	0.00025
Boron	0.005	0.00577	0.030	169	0.00614
Cadmium	0.000005	0.00000906	0.00123	169	0.000115
Calcium	2.3	21.9	75.8	169	24.3
Chromium	0.00005	0.0015	0.0158	164	0.0018
Cobalt	0.00005	0.00079	0.00557	168	0.000925
Copper	0.00011	0.00506	0.0360	169	0.00591
Iron	0.015	1.58	12.9	169	1.92
Lead	0.000025	0.00106	0.0101	169	0.00129
Lithium	0.00025	0.00264	0.0301	169	0.00302
Magnesium	0.277	2.85	7.19	169	3.08
Manganese	0.000691	0.071	0.405	169	0.0817
Mercury	0.000005	0.0000087	0.000075	169	0.0000101
Molybdenum	0.000025	0.000773	0.00224	169	0.000845
Nickel	0.00025	0.00175	0.0107	169	0.00201
Phosphorus	0.15	0.153	0.35	169	0.154
Potassium	0.081	0.663	4.22	169	0.753
Selenium	0.00005	0.000396	0.00208	169	0.000442
Silicon	0.505	3.8	24.4	169	4.33
Silver	0.000005	0.0000276	0.000201	168	0.0000329
Sodium	1.0	132	33.0	169	1.65
Strontium	0.0271	0.57	1.15	169	0.176
Thallium	0.000005	0.0000484	0.00027	169	0.0000538
Tin	0.00005	0.0000533	0.00018	169	0.0000556
Titanium	0.005	0.0379	0.417	169	0.0465
Uranium	0.000005	0.0000689	0.000263	169	0.0000769
Vanadium	0.0005	0.0037	0.033	169	0.00446
Zinc	0.00025	0.0972	0.0868	169	0.0116

All values expressed in mg/L

UCLM = Upper Confidence Limit of the Mean

Appendix B3. Summary of Metal Concentrations in Sediment from 2008 to 2012

Metals	Minimum	Mean	Maximum	Sample Size (n)	95% UCLM
Aluminum	6280	15451	30400	124	16141
Antimony	0.220	7.42	45.9	149	8.68
Arsenic	1.38	90.4	665	124	106
Barium	57.4	255	1090	124	277
Beryllium	0.240	0.479	1.22	145	0.505
Bismuth	0.050	2.88	10.0	157	3.45
Boron	2.50	2.5	2.5	36	2.50
Cadmium	0.250	2.02	8.71	128	2.28
Calcium	2080	10521	32500	124	11593
Chromium	2.78	37.3	135	124	41.5
Cobalt	6.07	20.4	56.0	124	21.6
Copper	13.9	117	584	124	135
Iron	7230	46007	106000	124	48284
Lead	2.09	40.8	250	146	48.0
Lithium	2.50	16.6	42.3	91	18.1
Magnesium	575	8662	21400	124	9246
Manganese	127	1421	5180	124	1566
Mercury	0.0740	0.258	0.810	124	0.283
Molybdenum	0.430	4.88	17	138	5.38
Nickel	3.51	46.3	130	124	51.5
Phosphorus	398	1565	3680	124	1643
Potassium	150	1500	3880	124	1608
Selenium	0.40	2.77	19.1	148	3.08
Silver	0.174	6.3	89.0	157	8.37
Sodium	50.0	316	19900	140	550
Strontium	19.7	67.5	190	124	72.9
Sulfur	1100	8703	27100	11	14199
Thallium	0.050	0.366	2.14	157	0.401
Tin	0.10	2.65	85.4	157	3.92
Titanium	16.1	481	1700	124	554
Uranium	0.0850	0.951	4.48	120	1.09
Vanadium	9.40	56.4	159	124	60.7
Zinc	73.8	219	581	124	236

All values expressed in mg/kg dry weight

UCLM = Upper Confidence Limit of the Mean

Appendix C

Food Chain Model and Predicted Moose, Snowshoe Hare, and Grouse Tissue Metal Concentrations

Appendix C. Food Chain Model and Predicted Moose, Snowshoe Hare, and Grouse Tissue Metal Concentrations

1. INTRODUCTION

Tissue concentrations for moose, snowshoe hare, and grouse were estimated using a food chain model. The food chain model predicts metal concentrations in animal tissue by estimating the fraction of metals that are retained in the tissues when wildlife ingests environmental media such as vegetation, soil and surface water. The food chain model followed the methodology described in Golder (2005).

This section provides details on the methodology of the food chain model and the modelled metal concentrations in the tissues of the terrestrial wildlife that may be hunted as country foods (e.g., moose, snowshoe hare, and grouse). The modelled metal concentrations were used in the country foods baseline study to assess the potential for these foods to affect human health.

2. METHODS

The following equation was used to predict terrestrial animal tissue concentrations:

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

where:

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

The terrestrial wildlife uptake equations used to estimate the concentrations in animal tissue (meat) from exposure to soil, vegetation, and water are presented in Table C1.

Table C1. Terrestrial Wildlife Metal Uptake Equations

Pathway	Equation
Soil ingestion	$C_{msoil} = BTF_{tissue\text{-}food}$ (day/kg) x C_{soil} (mg/kg) x IR_{soil} (mg/day) x fw x fp
Water ingestion	$C_{mwater} = BTF_{tissue\text{-}food}$ (day/kg) x C_{water} (mg/L) x IR_{water} (L/day) x fw x fp
Vegetation ingestion	$C_{mveg} = BTF_{tissue\text{-}food}$ (day/kg) x C_{veg} (mg/kg wet weight) x IR_{veg} (kg/day) x fw x fp
where: BTF = biotransfer factor (day/kg) IR = ingestion rate for moose, snowshoe hare, and grouse C = concentration fw = fraction of daily consumption (assumed 1; unitless) fp = fraction of the year the animal is onsite (unitless)	

2.1 Biotransfer Factors

The tissue uptake calculations were based on metal specific biotransfer factors (BTF), which are rates at which metals are taken up and absorbed into wildlife tissue from their food. Food-to-tissue BTFs are used for water and soil transfer calculations in the absence of BTFs for these media. This methodology is based on a document prepared for Health Canada by Golder (2005). No species-specific BTFs on moose and snowshoe hare were available, therefore cow BTFs were used (Table C2; US EPA 2005; RAIS 2010). The use of beef BTFs for wild mammals is considered to be a conservative approach (RAIS 2010).

There were no BTFs specifically for the grouse, and beef BTFs are inappropriate, therefore chicken BTFs were used (RAIS 2010). The chicken BTFs were obtained from the Pacific Northwest National Laboratory's (PNNL) report (Staven et al. 2003; US EPA 2005).

Table C2. Biotransfer Factors Used to Predict Metal Uptake into Terrestrial Wildlife Tissue

Metal	BTF_{beef} (day/kg)	Reference	$BTF_{chicken}$ (day/kg)	Reference
Aluminum	0.0015	1	0.8	3
Arsenic	0.002	1	0.83	2
Beryllium	0.001	1	0.009	2
Cadmium	0.00055	1	0.10625	4
Chromium	0.0055	1	0.2	2
Copper	0.01	1	0.5	2
Lead	0.0003	2	0.8	2,5
Mercury	0.25	1	0.03	2
Molybdenum	0.001	2	0.18	2
Nickel	0.006	1	0.001	2
Selenium	0.002265	4	1.12625	4
Silver	0.003	1	2	2
Thallium	0.04	1	0.8	2
Tin	0.08	2	0.8	2
Vanadium	0.0025	1	0.0003	4
Zinc	0.00009	4	0.00875	4

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

When BTF values were not available for a specific metal, the BTF for a metal with similar physiochemical characteristics was substituted. Metals were considered similar in their physiochemical characteristics if they were immediately above or below each other on the periodic table for elements. For example, the $BTF_{chicken}$ for aluminum was not available; therefore, the BTF value for gallium was substituted because gallium is below aluminum on the periodic table.

2.2 Metal Concentrations in Environmental Media

Mixture of berries were collected from the local study area including Alaska blueberry (*Vaccinium ovalifolium*), thinleaf huckleberry (*V. membranaceum*), Canada Buffaloberry (*Sheperdia Canadensis*), and bog blueberry (*V. uliginosum*), and included in the 2012 Terrestrial and Wetland Baseline (Rescan 2013b). Additional berry data including *V. ovalifolium* collected in 2009 from KSM project within the country foods study area were also included in the assessment. Lichen samples from 2 species (*Cladina stygia* and *Stereocaulon paschale*) and water sedge samples (*Carex Aquatilis*) were collected from the country foods study area in 2012 and analyzed for metal concentrations (Rescan 2013b). Additional vegetation data including willow leaves sample (*Salix spp.*) and perennial herb leaves samples of Sitka valerian (*Valeriana sitchensis*), and thinleaf huckleberry leaves (*V. membranaceum*) from KSM Project within the country foods study area was also included in the assessment. Overall, 20 berry samples, 15 lichen samples, 21 water sedge leaf samples, one willow leaf sample, five Sitka valerian leaf samples, and two thinleaf huckleberry leaf samples were included in the food chain model. Appendix A5 provides the statistical summaries of berry, lichen, and other vegetation tissue metal samples. The metal concentrations for vegetation used in the wildlife food chain model were the 95% Upper Confident Limit of the Mean (UCLM) metal concentrations of all vegetation types collected (berries, lichens, and vegetation leaves).

Data used from the soil sampling program included soil samples collected from depths ranging from 0 to 20 cm below ground surface (reference). The data used from the freshwater sampling program included surface water samples from lakes and streams within the country foods study area collected between 2007 to 2012 as part of KSM Project baseline studies and Brucejack Gold Mine baseline programs (Rescan 2013a). A summary of the data collected is presented in Table C3. These concentrations were used to predict the tissue metal concentrations in moose, snowshoe hare, and grouse.

Table C3. Summary of 95th Upper Confidence Level of the Mean Metal Concentrations in Vegetation Tissue, Soil, and Surface Water Samples

Metal	Vegetation Tissues (mg/kg wet weight)[1]	Soil (mg/kg)[2]	Surface Water (mg/L)[3]
Aluminum	106	21778	5.69
Arsenic	0.623	152	0.00685
Beryllium	0.0814	0.559	0.00025
Cadmium	0.129	0.430	0.000237
Chromium	0.186	46.3	0.00554
Copper	3.75	220	0.0196
Lead	0.308	24.4	0.00463
Mercury	0.0122	0.364	0.0000252
Molybdenum	0.182	19.6	0.00168
Nickel	1.30	30.8	0.00605
Selenium	0.252	2.42	0.00104
Silver	nd	1.30	0.000130
Thallium	0.0102	0.355	0.0000500
Tin	0.100	2.10	0.0000500
Vanadium	0.338	82.9	0.0152
Zinc	20.6	85.6	0.0375

[1] Source: Pooled berry fruit, lichen thallus, and leaves of water sedge, willow, Sitka valerian and berries. The total number of plant samples was n = 64.
[2] The total number of soil samples was n = 31.
[3] The total number of freshwater samples varies for different metals. (n = 164 for Cr and Co; n = 169 for Al, Ba, Be, Cu, Pb, Hg, Mo, Ni, Se, Tl, Sn, V and Zinc).

2.3 Terrestrial Wildlife Characteristics

Terrestrial wildlife characteristics are species-specific parameters that were used to estimate the amount of time an animal would spend in the area and the amount of environmental media that each species would be exposed to during that time. Table C4 presents the species-specific characteristics that were used to predict moose, snowshoe hare, and grouse tissue metal concentrations.

Table C4. Terrestrial Wildlife Characteristics

Receptor	Body Weight (kg)	Food Ingestion Rate (kg wet weight/day)	Vegetation Ingestion Rate (kg wet weight/day)	Soil Ingestion Rate (kg/day)	Water Ingestion Rate (L/day)	Fraction of Year at Site
Moose	461	9.95	9.8	0.15	25	1
Snowshoe Hare	1.35	0.109	0.105	0.0036	0.0135	1
Grouse	1.2	0.085	0.084	0.07	0.07	1

Surveys conducted in during the 2011 indicated that moose are present mainly to the west of Brucejack Lake and the 2010 summer observations were along the Bell-Irving River, Wildfire Creek and the Bowser River watersheds and overlapped with the country foods study area (Rescan 2013c). Moose winter observations were limited to the Access Road study area along the access road to the east of Bower Lake area, although no surveys were conducted along the Transmission Line South study area. While Moose are not likely to be exposed to the metal concentrations associated with the Mine site study area, downstream of Adit and Camp Creek, the environmental quality data (soil, water, vegetation) from this area was included in the assessment resulting in a conservative estimate of grouse tissue metal concentrations.

For moose, a non-migratory home range of 42 km^2 was assumed (Demarchi 2000). In addition, moose were assumed to be active in their home range for the entire year because during winter months they may attempt to forage for grass stems and twigs of woody plants and leaves of succulent shoots of shrubs and trees during the rest of the year (Bowyer, Ballenberghe, and Kie 2003). Therefore, as a conservative measure, the exposure time for moose was assumed to be 1.

For snowshoe hare, the home range is estimated to be between 0.057 to 0.1 km^2 (Adams 1959). Grouse home range of 0.4 km^2 (Ellison 1971); the country foods study area is large enough that it could overlap with the entire home range of both snowshoe hare and grouse. Therefore, the exposure time for both snowshoe hare and grouse was assumed to be one.

3. SAMPLE CALCULATION AND COMPLETE MODEL RESULTS

To calculate the amount of metals that each ingestion pathway contributes, an equation for all ingestion routes is presented in Table C5, followed by media specific equations. Table C5 also provides a sample calculation for thallium concentrations in moose tissue resulting from ingesting soil, water, and vegetation under the baseline scenario.

Table C5. Sample Calculation of Thallium Concentration in Moose Tissue due to Uptake from Soil, Surface Water, and Vegetation

$$C_{mtotal} = C_{msoil} + C_{mveg} + C_{mwater}$$

and:

$$C_{msoil} = BTF_{tissue\text{-}food} \times C_{soil} \times IR_{soil} \times fw \times fp$$

$$C_{mveg} = BTF_{tissue\text{-}food} \times C_{veg} \times IR_{veg} \times fw \times fp$$

$$C_{mwater} = BTF_{tissue\text{-}food} \times C_{water} \times IR_{water} \times fw \times fp$$

where:

C_{total} = total concentration of COPC in meat tissue from soil, vegetation and water consumption (mg/kg)
C_{msoil} = concentration of COPC in meat tissue from soil consumption (mg/kg)
C_{mveg} = concentration of COPC in meat tissue from vegetation consumption (mg/kg)

(continued)

Table C5. Sample Calculation of Thallium Concentration in Moose Tissue due to Uptake from Soil, Surface Water, and Vegetation (completed)

C_{mwater}	= concentration of COPC in meat tissue from water consumption (mg/kg)
$BTF_{tissue\text{-}food}$	= bio-transfer factor from food consumption to tissues for a selected metal (mg/kg)
C	= average concentration of metal in media (mg/kg)
IR	= ingestion rate of media (kg/day)
Fw	= fraction of daily consumption (assumed 1; unitless)
Fp	= fraction of the year the animal is onsite (unitless)

Calculation:

C_{msoil}	= 0.04 day/kg x 0.355 mg/kg x 0.15 kg/day x 1 x 1	= 0.002130 mg/kg
C_{mveg}	= 0.04 day/kg x 0.010238 mg/kg x 9.8 kg/day x 1 x 1	= 0.0040136 mg/kg
C_{mwater}	= 0.04 day/kg x 0.0000500 mg/L x 25 L/day x 1 x 1	= 0.0000500 mg/kg
C_{mtotal}	= 0.006194 mg/kg wet weight	

Tables C6, C7, and C8 present the modelled moose, snowshoe hare, and grouse concentrations for this baseline country foods assessment. Each ingestion pathway (i.e. soil, water, and vegetation) contributes to the total concentration of metals in moose, snowshoe hare, and grouse. These metal concentrations in moose, snowshoe hare, and grouse tissue were used in the country foods baseline assessment to calculate the estimated daily intake of metals for people who eat these foods from within country foods study area.

Table C6. Estimated Concentrations in Moose Meat

Metal	C_{msoil}	C_{mwater}	C_{mveg}	C_{mtotal}
Aluminum	$4.90 \times 10^{+00}$	2.14×10^{-01}	$1.56 \times 10^{+00}$	$6.68 \times 10^{+00}$
Arsenic[a]	4.54×10^{-02}	3.43×10^{-04}	1.22×10^{-02}	5.80×10^{-02}
Beryllium	8.38×10^{-05}	6.25×10^{-06}	7.97×10^{-04}	8.87×10^{-04}
Cadmium	3.54×10^{-05}	3.26×10^{-06}	6.94×10^{-04}	7.32×10^{-04}
Chromium	3.82×10^{-02}	7.62×10^{-04}	1.00×10^{-02}	4.90×10^{-02}
Copper	3.30×10^{-01}	4.90×10^{-03}	3.68×10^{-01}	7.03×10^{-01}
Lead	1.10×10^{-03}	3.48×10^{-05}	9.06×10^{-04}	2.04×10^{-03}
Mercury	1.37×10^{-02}	1.58×10^{-04}	3.00×10^{-02}	4.38×10^{-02}
Molybdenum	2.94×10^{-03}	1.79×10^{-03}	4.21×10^{-05}	4.77×10^{-03}
Nickel	2.77×10^{-02}	9.07×10^{-04}	7.66×10^{-02}	1.05×10^{-01}
Selenium	8.22×10^{-04}	5.87×10^{-05}	5.60×10^{-03}	6.48×10^{-03}
Silver	5.85×10^{-04}	9.72×10^{-06}	nd	5.95×10^{-04}
Thallium	2.13×10^{-03}	5.00×10^{-05}	4.01×10^{-03}	6.19×10^{-03}
Tin	2.52×10^{-02}	1.00×10^{-04}	7.86×10^{-02}	1.04×10^{-01}
Vanadium	3.11×10^{-02}	9.50×10^{-04}	8.28×10^{-03}	4.03×10^{-02}
Zinc	1.16×10^{-03}	8.43×10^{-05}	1.82×10^{-02}	1.94×10^{-02}

nd: not determined
All concentrations are expressed in mg/kg wet weight.
[a] Total arsenic concentration calculated in the moose meat was converted into inorganic arsenic concentration before being used in any of the risk calculations. Inorganic arsenic concentrations were estimated based on proportions of inorganic arsenic to total arsenic concentrations in Schoof et al. (1999) and were used in the country foods baseline assessments calculations. See section 9.2.2 for further explanation.
C_{msoil}: concentration of COPC in meat tissue from soil consumption (mg/kg)
C_{mwater} : concentration of COPC in meat tissue from water consumption (mg/kg)
C_{mveg}: concentration of COPC in meat tissue from vegetation consumption (mg/kg)
C_{mtotal}: total concentration of COPC in meat tissue from soil, vegetation and water consumption (mg/kg)

Table C7. Estimated Concentrations in Snowshoe Hare Meat

Metal	C_{msoil}	C_{mwater}	C_{mveg}	C_{mtotal}
Aluminum	1.17×10^{-01}	1.11×10^{-03}	1.68×10^{-02}	1.35×10^{-01}
Arsenic[a]	1.08×10^{-03}	1.78×10^{-06}	1.31×10^{-04}	1.22×10^{-03}
Berrylium	2.00×10^{-06}	3.24×10^{-08}	8.57×10^{-06}	1.06×10^{-05}
Cadmium	8.46×10^{-07}	1.69×10^{-08}	7.45×10^{-06}	8.32×10^{-06}
Chromium	9.12×10^{-04}	3.95×10^{-06}	1.08×10^{-04}	1.02×10^{-03}
Copper	7.88×10^{-03}	2.56×10^{-05}	3.95×10^{-03}	1.19×10^{-02}
Lead	2.62×10^{-05}	1.80×10^{-07}	9.73×10^{-06}	3.61×10^{-05}
Mercury	3.26×10^{-04}	8.17×10^{-07}	3.22×10^{-04}	6.49×10^{-04}
Molybdenum	7.01×10^{-05}	2.18×10^{-07}	1.92×10^{-05}	8.96×10^{-05}
Nickel	6.61×10^{-04}	4.71×10^{-06}	8.23×10^{-04}	1.49×10^{-03}
Selenium	1.96×10^{-05}	3.04×10^{-07}	6.02×10^{-05}	8.01×10^{-05}
Silver	1.40×10^{-05}	5.04×10^{-08}	nd	1.40×10^{-05}
Thallium	5.08×10^{-05}	2.59×10^{-07}	4.31×10^{-05}	9.42×10^{-05}
Tin	6.01×10^{-04}	5.19×10^{-07}	8.45×10^{-04}	1.45×10^{-03}
Vanadium	7.42×10^{-04}	4.93×10^{-06}	8.90×10^{-05}	8.36×10^{-04}
Zinc	2.76×10^{-05}	4.37×10^{-07}	1.95×10^{-04}	2.23×10^{-04}

nd: not determined
All concentrations are expressed in mg/kg wet weight.
[a] Total arsenic concentration calculated in the moose meat was converted into inorganic arsenic concentration before being used in any of the risk calculations. Inorganic arsenic concentrations were estimated based on proportions of inorganic arsenic to total arsenic concentrations in Schoof et al. (1999) and were used in the country foods baseline assessments calculations. See section 9.2.2 for further explanation.
C_{msoil}: concentration of COPC in meat tissue from soil consumption (mg/kg)
C_{mwater} : concentration of COPC in meat tissue from water consumption (mg/kg)
C_{mveg}: concentration of COPC in meat tissue from vegetation consumption (mg/kg)
C_{mtotal}: total concentration of COPC in meat tissue from soil, vegetation and water consumption (mg/kg)

Table C8. Estimated Concentrations in Grouse Meat

Metal	C_{msoil}	C_{mwater}	C_{mveg}	C_{mtotal}
Aluminum	$1.22 \times 10^{+03}$	3.19×10^{-01}	$7.15 \times 10^{+00}$	$1.23 \times 10^{+03}$
Arsenic[a]	$8.80 \times 10^{+00}$	3.98×10^{-04}	4.34×10^{-02}	$8.84 \times 10^{+00}$
Beryllium	1.56×10^{-02}	7.00×10^{-06}	2.73×10^{-03}	1.84×10^{-02}
Cadmium	3.20×10^{-03}	1.76×10^{-06}	1.15×10^{-03}	4.35×10^{-03}
Chromium	6.48×10^{-01}	7.76×10^{-05}	3.13×10^{-03}	6.52×10^{-01}
Copper	$7.71 \times 10^{+00}$	6.86×10^{-04}	1.58×10^{-01}	$7.87 \times 10^{+00}$
Lead	$1.36 \times 10^{+00}$	2.60×10^{-04}	2.07×10^{-02}	$1.38 \times 10^{+00}$
Mercury	7.64×10^{-04}	5.29×10^{-08}	3.09×10^{-05}	7.95×10^{-04}
Molybdenum	2.47×10^{-01}	2.12×10^{-05}	2.76×10^{-03}	2.50×10^{-01}
Nickel	2.15×10^{-03}	4.23×10^{-07}	1.09×10^{-04}	2.26×10^{-03}
Selenium	1.91×10^{-01}	8.17×10^{-05}	2.39×10^{-02}	2.15×10^{-01}
Silver	1.82×10^{-01}	1.82×10^{-05}	nd	1.82×10^{-01}
Thallium	1.99×10^{-02}	2.80×10^{-06}	6.88×10^{-04}	2.06×10^{-02}

(continued)

Table C8. Estimated Concentrations in Grouse Meat (completed)

Metal	C_{msoil}	C_{mwater}	C_{mveg}	C_{mtotal}
Tin	1.18 x 10^{-01}	2.80 x 10^{-06}	6.74 x 10^{-03}	1.24 x 10^{-01}
Vanadium	1.74 x 10^{-03}	3.19 x 10^{-07}	8.52 x 10^{-06}	1.75 x 10^{-03}
Zinc	5.24 x 10^{-02}	2.29 x 10^{-05}	1.52 x 10^{-02}	6.76 x 10^{-02}

nd = not determined
All concentrations are expressed in mg/kg wet weight.
[a] *Total arsenic concentration calculated in the moose meat was converted into inorganic arsenic concentration before being used in any of the risk calculations. Inorganic arsenic concentrations were estimated based on proportions of inorganic arsenic to total arsenic concentrations in Schoof et al. (1999) and were used in the country foods baseline assessments calculations. See section 9.2.2 for further explanation.*
C_{msoil}: *concentration of COPC in meat tissue from soil consumption (mg/kg)*
C_{mwater} : *concentration of COPC in meat tissue from water consumption (mg/kg)*
C_{mveg}: *concentration of COPC in meat tissue from vegetation consumption (mg/kg)*
C_{mtotal}: *total concentration of COPC in meat tissue from soil, vegetation and water consumption (mg/kg)*

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Appendix D

Summary of Measured Metal Concentration in Biota

Appendix D1. Summary of Metal Concentrations in Fish Tissue from 2011 to 2012

Metals	Minimum	Mean	Maximum	95% UCLM
Aluminum	1.0	12.0	79.9	24.6
Antimony	0.0150	0.0160	0.0170	0.0224
Arsenic	0.0120	0.0265	0.050	0.0334
Barium	0.0110	0.276	1.33	0.509
Cadmium	0.00250	0.00395	0.00720	0.00507
Calcium	95.2	266	637	372
Chromium	0.050	0.158	0.590	0.266
Cobalt	0.0340	0.0713	0.103	0.0838
Copper	0.321	0.582	1.25	0.760
Lead	0.010	0.010	0.010	0.010
Magnesium	247	293	330	305
Manganese	0.154	0.446	1.15	0.593
Mercury	0.0125	0.0242	0.0385	0.0289
Molybdenum	0.0050	0.0050	0.0050	0.0050
Nickel	0.050	0.0664	0.140	0.0863
Selenium	0.520	0.830	1.04	0.912
Strontium	0.0780	0.419	1.14	0.630
Thallium	0.0050	0.00946	0.0240	0.0134
Tin	0.0250	0.0364	0.109	0.0512
Vanadium	0.050	0.070	0.270	0.107
Zinc	5.06	7.31	10.8	8.33

All values expressed in mg/kg wet weight

Sample size (n) = 11

UCLM = Upper Confidence Limit of the Mean

Appendix D2. Summary of Metal Concentrations in Vegetation from 2008 to 2012

	Berry Metal Concentrations (n = 19)				Lichen Thallus Metal Concentrations (n = 15)				Water Sedge, Willow, Sitka Valerian, and Berry Leaves (n = 30)			
	Minimum	Average	Maximum	95% UCLM	Minimum	Average	Maximum	95% UCLM	Minimum	Average	Maximum	95% UCLM
Aluminum	1	3.81	10.3	4.76	137	303	736	388	0.446	7.95	52.6	11.3
Antimony	0.005	0.005	0.005	0.005	0.0079	0.0751	0.351	0.112	0.000675	0.0182	0.025	0.0215
Arsenic	0.005	0.005	0.005	0.005	0.0756	1.6	7.31	2.49	0.000675	0.0419	0.255	0.0579
Barium	0.294	2.1	5.28	2.58	6.06	20.3	57.3	26.9	0.572	10.4	25.1	12.5
Beryllium	0.05	0.05	0.05	0.05	0.0046	0.0139	0.0345	0.018	0.00675	0.11	0.15	0.13
Bismuth	0.015	0.015	0.015	0.015	0.0044	0.00796	0.0171	0.00943	0.00203	0.109	0.15	0.129
Boron	nd	nd	nd	nd	0.3	1.57	3.23	1.94	nd	nd	nd	nd
Cadmium	0.0025	0.00574	0.0235	0.00808	0.0096	0.0496	0.109	0.0647	0.000338	0.134	1.74	0.251
Calcium	142	248	555	287	336	1590	3640	1990	138	2350	8520	2930
Cesium	nd	nd	nd	nd	0.0579	0.303	2.07	0.534	nd	nd	nd	nd
Chromium	0.05	0.05	0.05	0.05	0.165	0.273	0.407	0.306	0.00675	0.182	0.25	0.215
Cobalt	0.01	0.01	0.01	0.01	0.112	0.203	0.466	0.245	0.00147	0.131	0.63	0.181
Copper	0.418	0.839	1.47	0.956	0.95	2.05	5.65	2.56	0.0901	4.67	21.8	6.42
Gallium	nd	nd	nd	nd	0.0256	0.0758	0.21	0.0957	nd	nd	nd	nd
Iron	1	4.19	10.6	5.18	92.1	412	1120	520	0.661	8.15	32.2	15.4
Lead	0.01	0.01	0.01	0.01	0.248	0.829	3.08	1.14	0.00135	0.0372	0.05	0.0437
Lithium	0.05	0.198	0.25	0.234	0.026	0.132	0.426	0.179	0.00675	0.182	0.25	0.215
Magnesium	67.3	99.2	143	109	158	248	371	278	40.9	1030	1890	1210
Manganese	2.38	27	62.8	34.1	12.3	80.7	208	108	0.542	301	1140	387
Mercury	0.0005	0.000579	0.002	0.000716	0.0123	0.0338	0.0625	0.0401	0.00025	0.0025	0.0072	0.003
Molybdenum	0.005	0.0768	0.318	0.115	0.0332	0.0909	0.219	0.117	0.00078	0.21	0.989	0.288
Nickel	0.05	0.335	2.42	0.567	0.408	1.18	3.65	1.57	0.0621	1.45	6.21	1.94
Phosphorus	119	265	457	307	168	355	672	415	58.1	211	732	355
Potassium	730	1250	2370	1440	460	926	2140	1150	329	999	2460	1480
Rhenium	nd	nd	nd	nd	0.001	0.001	0.001	0.001	nd	nd	nd	nd
Rubidium	nd	nd	nd	nd	0.81	2.37	8.57	3.28	nd	nd	nd	nd
Selenium	0.1	0.1	0.1	0.1	0.021	0.0465	0.105	0.0559	0.0135	0.364	0.5	0.43
Sodium	10	76.4	100	92.6	20	22.4	55	26.5	1.35	12.1	78.9	27.8
Strontium	0.3	0.86	1.7	1.04	1.84	5.09	19.7	7.09	0.636	15.2	60.4	19.5
Tellurium	nd	nd	nd	nd	0.002	0.00233	0.0069	0.00291	nd	nd	nd	nd
Thallium	0.005	0.005	0.005	0.005	0.00427	0.00831	0.025	0.0107	0.000675	0.0118	0.038	0.0143
Thorium	nd	nd	nd	nd	0.0076	0.0243	0.0658	0.0306	nd	nd	nd	nd
Tin	0.025	0.153	0.386	0.191	0.0099	0.0262	0.0662	0.0331	0.00338	0.073	0.1	0.0861
Titanium	0.05	0.393	0.5	0.468	2.24	13.3	27.7	16.2	0.0203	0.139	0.526	0.251
Uranium	0.001	0.001	0.001	0.001	0.0022	0.00973	0.0218	0.0119	0.000135	0.00364	0.005	0.0043
Vanadium	0.05	0.05	0.05	0.05	0.196	0.75	1.66	0.896	0.00675	0.182	0.25	0.215
Yttrium	nd	nd	nd	nd	0.0471	0.164	0.402	0.208	nd	nd	nd	nd
Zinc	0.77	1.62	3.26	1.89	5.29	12.4	20	14.6	0.364	29.4	64.7	35.4
Zirconium	nd	nd	nd	nd	0.042	0.124	0.229	0.148	nd	nd	nd	nd

All values expressed in mg/kg wet weight

UCLM = Upper Confidence Limit of the Mean

Appendix E

Sample Calculation of Estimated Daily Intake of Arsenic for a Toddler Consuming Moose Tissue

Engineers and Scientists

Appendix E. Sample Calculation of Estimated Daily Intake of Arsenic for a Toddler Consuming Moose Tissue

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

$EDI_{countryfood}$ = estimated daily intake of country food (mg/kg BW/day)
IR = ingestion rate (kg/day)
$C_{country\ food}$ = metal concentration in country food (mg/kg ww)
fs = fraction of year/week consuming country foods
BW = receptor body weight (kg)
P_{as} (in moose) = proportion of inorganic arsenic relative to total arsenic concentration

Parameter	Value
IR	0.0916 kg/day
C_{moose}	0.0580 mg/kg ww
F_s	0.997
BW	16.5 kg
P_{as}	0.0078 (from Schoof et al. 1999)

$$EDI_{countryfood} = \frac{0.0916 \times 0.997 \times 0.0580 \times (0.0078)}{16.5}$$

$$EDI_{countryfood} = 2.49 \times 10^{-6}\ mg/(kg_{BW} \times day)$$

Appendix F

Sample Calculation of Estimated Daily Lifetime Exposure of Arsenic for an Adult Consuming Snowshoe Hare Tissue

Appendix F. Sample Calculation of Estimated Lifetime Daily Exposure of Arsenic for an Adult Consuming Snowshoe Hare Tissue

$$ELDE_{country\ food} = \frac{IR \times F_s \times C_{country\ food} \times Pas\ \times\ YE}{BW \times LE}$$

$ELDE_{country\ food}$ =	estimated lifetime daily intake of country food (mg/kg BW/day)
IR =	ingestion rate (kg/day)
F_s =	fraction of year consuming country food (unitless)
$C_{countryfood}$ =	metal concentration in country food (mg/kg)
P_{as} (in snowshow hare) =	proportion of inorganic arsenic relative to total arsenic concentration
YE =	years exposed (yr)
BW =	receptor body weight (kg)
LE =	life expectancy (yr)

Parameter	**Value**
IR	0.348 kg/day
F_s	0.03288
$C_{snowshoe\ hare}$	0.00122 mg/kg ww
P_{as} (in snowshow hare)	0.0078 (from Schoof et al. 1999)
YE	80
LE	80
BW	70.7 kg

$$ELDE_{country\ food} = \frac{0.348 \times 0.03288 \times 0.00122 \times (0.0078) \times 80}{70.7 \times 80}$$

$$ELDE_{country\ food} = 1.53 \times 10^{-09}\ (\frac{mg}{kg_{BW}\ \times\ day})$$

Appendix G

Recommended Maximum Weekly Intake Rates for Country Foods

Table G1. Sample Calculation of RMWI in Toddlers Consuming Moose

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

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

COPC	TRV_{metal} mg/kg/d	$BW_{toddler}$ kg	C_{moose} mg/kg	$RMWI_{metal}$ kg/week
Aluminum	1	16.5	6.68	17.3
Arsenic (inorganic)	0.0003	16.5	0.057990	76.9
Beryllium	0.002	16.5	0.0009	260
Cadmium	0.001	16.5	0.000732	158
Chromium	0.001	16.5	0.0490	2.36
Copper	0.141	16.5	0.703	23.2
Lead	0.0036	16.5	0.00204	204
Mercury	0.0003	16.5	0.0438	0.791
Molybdenum	23	16.5	0.0048	557,124
Nickel	0.025	16.5	0.105	27.5
Selenium	0.0062	16.5	0.00648	110.5
Silver	0.005	16.5	0.000595	971
Thallium	0.00007	16.5	0.00619	1.31
Tin	0.6	16.5	0.104	667
Vanadium	0.009	16.5	0.0403	25.8
Zinc	0.57	16.5	0.0194	3,389

Highlighted cells indicate the lowest final RMWI = 0.791 kg/week

Table G2. Summary of Recommended Maximum Weekly Intakes (kg/week) for Adults

	RMWI				
COPC	**Moose**	**Grouse**	**Snowshoe Hare**	**Berries**	**Dolly Varden/Bull Trout**
Aluminum	74.1	**0.403**	3,670	105	20.1
Arsenic (inorganic)	330	1.61	15,701	61.5	44.5
Beryllium	1,115	53.8	93,381	19.5	nd
Cadmium	676	114	59,503	63.4	97.7
Chromium	10.10	0.76	483	9.85	**1.87**
Copper	99.2	8.87	5,883	72.3	91.8
Lead	875	1.29	49,390	177	178.2
Mercury	**3.39**	187	**229**	214	8.07
Molybdenum	2,906,147	55,521	154,736,132	115,931	2,771,440
Nickel	118	5,469	8,316	22.8	143
Selenium	435	13.1	35,229	28.1	3.10
Silver	4,162	13.6	176,660	nd	nd
Thallium	5.59	1.68	368	**6.81**	2.60
Tin	2,858	2,390	205,302	1,620	5,806
Vanadium	110.49	2,546	5,330	88.6	41.9
Zinc	14,522	4,171	1,262,664	149	33.9
Lowest RMWI	**3.39**	**0.403**	**229**	**6.81**	**1.87**

RMWI = recommended maximum weekly intake of food (kg/week)
Highlighted cells indicate the lowest final RMWI for each country food
nd = not determined

Table G3. Summary of Recommended Maximum Weekly Intakes (kg/week) for Toddlers

	RMWI				
COPC	**Moose**	**Grouse**	**Snowshoe Hare**	**Berries**	**Dolly Varden/Bull Trout**
Aluminum	17.3	**0.0941**	856	24.5	4.70
Arsenic (inorganic)	76.9	0.376	3,664	14.4	10.4
Beryllium	260	12.6	21,793	4.54	nd
Cadmium	158	26.6	13,887	14.8	22.8
Chromium	2.36	0.18	112.8	2.30	**0.436**
Copper	23.2	2.07	1,373	16.9	21.4
Lead	204	0.30	11,527	41.4	41.58
Mercury	**0.791**	43.6	**53.4**	49.9	0.922
Molybdenum	557,124	10,644	29,663,751	22,225	531,300
Nickel	27.5	1,276	1,941	5.32	33.5
Selenium	111	3.34	8,943	6.55	0.72
Silver	971	3.17	41,229	nd	nd
Thallium	1.31	0.393	85.8	**1.59**	0.606
Tin	667	558	47,913	378	1,355
Vanadium	25.8	594	1,244	20.7	9.78
Zinc	3,389	974	294,681	34.8	7.90
Lowest RMWI	**0.791**	**0.0941**	**53.4**	**1.59**	**0.436**

RMWI = recommended maximum weekly intake of food (kg/week)

Highlighted cells indicate the lowest final RMWI for each country food

nd = not determined