21. HUMAN HEALTH EFFECTS ASSESSMENT

21.1 INTRODUCTION

Human health is included as a valued component (VC) in the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS) for the Harper Creek Project (the Project) because of its fundamental importance to people who live and work in the region where the proposed Project will be developed. The purpose of this chapter is to assess the potential exposure of human receptors to potential toxicological and biophysical effects of the proposed Project through inhalation of air, through the consumption of country foods and drinking water, and from exposure to noise.

The establishment of a mine and associated activities including blasting; plant, road, and camp construction; mine operation; and the transport and management of chemicals, waste rock, and tailings have the potential to generate noise; release pollutants in the air, soil, and water; and lead to the uptake of chemicals by vegetation and country foods, potentially affecting the health of humans using the area. In other words, the Project's Construction, Operations, Closure, and Post-Closure phases may have the potential to directly and indirectly affect human health via environmental media, such as air quality, the quality of country foods, drinking water quality, and noise levels. For these reasons, human health was selected as a VC and potential Project-related effects to human health due to air quality, country foods quality, drinking water quality, and noise were identified as important components of the assessment in the Project's Application Information Requirements (AIR; BC EAO 2011).

Canadian federal and provincial governments and health officials have accepted the WHO's definition of holistic health: "A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO 1948). Thus "health" is recognized as comprising more than just physical health; social, nutritional, and economic factors, as well as customs and cultural practices, also play a role in a person's overall health and feeling of well-being. Other important determinants of human health include income, education, social status, and access to primary health care, which are assessed separately in Chapters 17, 18, 20, and 22, and are therefore not included here.

Biophysical environmental factors have the potential to affect the physical health of human receptors directly through chemical means (e.g., quality of air, water, and country foods) and noise. Physical health due to interaction with biophysical environmental components (i.e., noise, air quality, water quality, and country foods quality) is assessed in this chapter.

All chemicals or stressors from anthropogenic or natural sources have the potential to cause toxicological or physical health effects. However, three components have to be present in order for a health risk to exist.

1. A toxic chemical has to be released at a sufficiently high concentration to cause toxicological effects.

2. A human receptor has to be present.
3. A pathway must exist from the point of release of the chemical to the human receptor and the human receptor must be able to take up the chemical.

These components also apply to the assessment of health effects from noise exposure (i.e., there must be a source of noise, a receptor for noise, and a pathway from the noise source to receptor). The purpose of the human health assessment is to examine these three components and to determine whether residual effects to human health exist, after the successful implementation of mitigation measures.

The human health effects assessment does not address occupational exposures. Health and safety of employees while working is addressed by various legislation and codes in British Columbia (BC) such as the Occupational Health and Safety Regulation (BC Reg. 296/97), associated policies and guidelines administered by WorkSafe BC, and the *Health, Safety and Reclamation Code for Mines in British Columbia* (BC MEMPR 2008) administered by the British Columbia Ministry of Energy and Mines. Since the proponent must adhere to these occupational health and safety requirements to ensure provision of a safe working environment, there is no additional need to consider on-duty worker health and safety in the Application/EIS. Safety and human health concerns for on-shift workers will be addressed separately in site- and/or activity-specific Health and Safety Plans that will be developed before Construction.

However, off-duty workers that reside at worker camps should be considered as potential human receptors (Health Canada 2010e). In addition, this human health assessment considers people who could enter the Project and surrounding areas on an occasional and temporary basis (e.g., campers, hunters).

This chapter follows the effects assessment methodology described in Chapter 8, Assessment Methodology, of this Application/EIS.

21.2 Regulatory and Policy Framework

The inclusion of human health assessment in the environmental assessment (EA) process in Canada has been recognized by the federal government and by the Province of BC under various statutory and policy requirements (Health Canada 1999a, 2010e). Under BC's *Environmental Assessment Act* (2002), an EA 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* effect."

Under the *Canadian Environmental Assessment Act* (1992), 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 Act requires that the environment be protected from significant adverse environmental effects caused by a designated project.

The assessment of human health effects has been prepared to fulfill the requirements of the AIR as approved by the British Columbia Environmental Assessment Office (BC EAO) and the guidance document titled *Useful Information for Environmental Assessments* authored by Health Canada (Health

Canada 2010e). The human health effects assessment also meets the requirements as outlined in the Background Information scoping document (CEAA 2011) released by the Canadian Environmental Assessment Agency for the Project.

Health Canada provides guidance on the type of information required to be included in the effects assessment for human health, including air quality, country foods quality, drinking water quality, and noise (Health Canada 2010e).

Standards, guidelines, objectives, and/or criteria for air quality and drinking water quality are set by the provincial and federal governments with the goal to protect human health (Table 21.2-1). For the purpose of the assessment of noise effects on the general public, guidance from Health Canada and international guidance documents (Table 21.2-1) were followed.

Detailed thresholds and guidelines used to evaluate potential health effects are presented below in Sections 21.2.1 to 21.2.4.

Table 21.2-1. Summary of Statutes, Regulations, and Guidelines for the Protection of Human Health

Name	Level of Government	Description
Drinking Water Protection Act (2001)	British Columbia	The *Drinking Water Protection Act* (2001) applies to all water systems other than single-family dwellings (and other systems excluded through the regulation). Section 23(1) states that "*a person must not introduce anything or cause or allow anything to be introduced into a domestic water system, a drinking water source, a well recharge zone, or an area adjacent to a drinking water source.*"
Drinking Water Protection Regulation (BC Reg. 200/2003)	British Columbia	Schedule A of the Drinking Water Protection Regulation (BC Reg. 200/2003) lists water quality standards for potable water.
Water Quality Guidelines (Criteria) Reports (BC MOE 2013h)	British Columbia	The approved and working water quality guidelines include thresholds of metals and nutrients for drinking water supply.
Guidelines for Canadian Drinking Water Quality 2012 (Health Canada 2012)	Federal	The Guidelines for Canadian Drinking Water Quality are established by the Federal-Provincial-Territorial Committee on Drinking Water and published by Health Canada. Each guideline for chemical, physical, microbiological, and radiological parameters is established based on current, published scientific research related to health effects, aesthetic effects, and operational considerations.
Air Quality Objectives and Standards (BC MOE 2013a)	British Columbia	This document provides air quality levels for specific pollutants that are determined to be necessary to protect human health and/or the environment. It usually includes a numeric pollutant concentration, averaging time, rules or guidance on sampling methodology, and how the objectives or standards are to be applied.

(continued)

Table 21.2-1. Summary of Statutes, Regulations, and Guidelines for the Protection of Human Health (completed)

Name	Level of Government	Description
Canadian Ambient Air Quality Standards (Environment Canada 2013)	Federal	Canadian Ambient Air Quality Standards are health-based air quality objectives for pollutant concentrations in outdoor air. Under the Air Quality Management System, Environment Canada and Health Canada established air quality standards for fine particulate matter and ground-level ozone, two pollutants of concern to human health and the major components of smog.
Guidelines for Community Noise (WHO 1999)	International	The scope of the World Health Organization's (WHO) effort to derive guidelines for community noise is to consolidate actual scientific knowledge on the health impacts of community noise and to provide guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in non-industrial environments.

21.2.1 Air Quality

Managing air quality is a partnership between multiple government jurisdictions and stakeholders including municipal, regional, provincial, and federal governments.

Regional and municipal governments can also develop bylaws to control emissions from such sources as open burning and vehicle idling. The Regional District of Thompson-Nicola, where the Project is located, currently has an anti-idling program and open-burning bylaw, which is part of the Kamloops Airshed Management Plan (City of Kamloops 2012). It is understood that clean air in the area is valued and has been identified as a "prominent sustainability component" (City of Kamloops 2012). The District of Clearwater Official Community Plan (District of Clearwater 2012) includes an objective to "Ensure the continuation of a fresh, clean and safe airshed." The District of Barriere Official Community Plan (District of Barriere 2011) includes the objective "To move towards a level of air quality that does not impact the environment or population in a negative manner…To encourage the development and adoption of policies that contributes to the reduction and prevention of air pollution."

The *Environmental Management Act* (EMA; 2003) and Waste Discharge Regulation (BC Reg. 320/2004) are the most important pieces of legislation for air quality in BC. The Waste Discharge Regulation, under the EMA, stipulates that it is applicable to mining and mining activities such as clearing, burning, and incineration (BC Reg. 320/2004). Many codes of practice and regulations are also in development and review under the EMA, which include the Hazardous Waste Regulation (B.C. Reg. 63/88), the Open Burning Smoke Control Regulation (B.C. Reg. 145/93), and the Small Electrical Power Generating Facility Code of Practice (BC MOE 2011).

The *Canadian Environmental Protection Act* (CEPA; 1999), which came into force on March 31, 2000, is an important part of Canada's federal environmental legislation aimed at preventing pollution and protecting the environment and human health. The CEPA also regulates emission sources that lie beyond provincial authorities' jurisdiction, such as motor vehicles and fuel, and off-road engines (BC MOE 2013c).

The federal government has set Canadian Ambient Air Quality Standards (CAAQS) and National Ambient Air Quality Objectives (NAAQOs). CAAQSs are intended to be achievable targets that will reduce health and environmental risks within a specific timeframe, whereas NAAQOs identify benchmark levels of protection for people and the environment. Within the NAAQO, three objective values have been recommended: maximum desirable, maximum acceptable, and maximum tolerable. The province also has the authority to develop air quality standards and guidelines, regulate point and area sources, and require the preparation of airshed management plans (BC MOE 2013f). The BC Ambient Air Quality Objectives (AAQOs) are generally similar to the CAAQSs and NAAQOs; however, some pollutants are only regulated by either the federal or the provincial government. Three tiers of BC AAQOs have been established (Level A, Level B, and Level C), which are broadly comparable to the federal desirable, acceptable, and tolerable levels discussed above. The federal and provincial ambient air quality criteria for particulate matter are summarized in Table 21.2-2.

Table 21.2-2. Federal and Provincial Ambient Air Quality Criteria

		Concentrations (µg/m³)					
		Canadian Ambient Air Quality Standards [a]			BC Ambient Air Quality Objectives [b]		
Pollutant	Averaging Time	Maximum Desirable	Maximum Acceptable	Maximum Tolerable	Level A	Level B	Level C
PM_{10}	24-hour	-	-	-	-	50	-
$PM_{2.5}$	24-hour	-	27 [c]	-	-	25 [d]	-
	Annual	-	8.8 [c]	-	-	8 [e]	-

Notes:
(-) dash indicates not applicable.
PM_{10} = particulate matter less than 10 µm in diameter.
$PM_{2.5}$ = particulate matter less than 2.5 µm in diameter.
[a] *CCME (1999).*
[b] *BC MOE (2013a).*
[c] *New Canada-wide standards for $PM_{2.5}$ effective in 2020* (Environment Canada 2013).
[d] *Based on annual 98th percentile value.*
[e] *BC objective of 8 µg/m³ and planning goal of 6 µg/m³ were established in 2009.*
Shaded cells indicate the guidelines used in this assessment.

The Canadian Council of Ministers of the Environment (CCME) developed new CAAQSs for $PM_{2.5}$ (particulates with diameter less than 2.5 micrometres [µm]) in 2000, with maximum acceptable concentrations of 30 µg/m³ based on the annual 98th percentile averaged over three consecutive years (CCME 2012). Table 21.2-2 shows the $PM_{2.5}$ CAAQS that will be applicable in 2020, which were used in the assessment (BC MOE 2013a). The PM_{10} CAAQS was not updated in 2000. In 2009, new ambient air quality criteria for $PM_{2.5}$ were developed in BC (BC MOE 2013e). The 24-hour $PM_{2.5}$ objective of 25 µg/m³, based on an annual 98th percentile, is more stringent than the CAAQS for $PM_{2.5}$. BC also established an annual average objective of 8 µg/m³ for $PM_{2.5}$ and a continuous improvement annual target of 6 µg/m³. The most conservative available air quality criteria were used in this assessment (shaded cells in Table 21.2-2).

The Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia (BC MOE 1979) developed dustfall objectives ranging from 1.7 to 2.9 mg/dm^2/day, averaged over 30 days. However, dustfall is an environmental or nuisance concern rather than a human health concern (Health Canada 1999b; WHO 2000; US EPA 2012), thus dustfall was not evaluated in this chapter (see Chapter 9, Air Quality, for dustfall results).

Other air contaminants include ground-level ozone, volatile organic compounds (VOCs), nitrogen dioxide, sulphur dioxide, and carbon monoxide. Ground-level ozone is formed in a series of complex atmospheric reactions that involve primary air pollutants such as nitrogen oxides and VOCs. The CALPUFF model used for air quality modelling (see Chapter 9) does not include routines for calculating formation rates of ground level ozone. VOC, nitrogen dioxide, sulphur dioxide, and carbon monoxide emission levels associated with the Project are expected to be minimal and are not expected to have a significant effect on air quality. During the Operations phase, power for the Project will be supplied by BC Hydro rather than diesel generators. Additionally, since October 2010, sulphur content in diesel fuel has been reduced to a maximum of 15 mg/kilogram (kg), and as a result diesel combustion associated with Project activities is expected to produce minimal amounts of sulphur dioxide. Additionally, these contaminants were not required by the BC MOE as part of the air quality Conceptual Model Plan (Appendix 9-C), and thus were not subject to assessment as specified in the AIR (BC EAO 2011). As required in the AIR, the assessment of potential Project-related air quality effects on human health is focussed on the potential effects of airborne particulate matter.

21.2.2 Country Foods Quality

Country foods are defined as animals, plants, or fungi used by people for medicinal or nutritional purposes that are harvested through hunting, gathering, or fishing (see Chapter 22 Current use of Lands and Resources for Traditional Purposes for more information on these land use activities by Aboriginal groups). The quality of country foods is directly related to the quality of the surrounding environmental media (e.g., soil, water, and vegetation). Human health may be affected by consumption of country foods that contain contaminants that occur naturally or as a result of anthropogenic activities.

For assessing the potential for contamination of country foods under baseline and Project conditions, Health Canada indicates that the human health risk assessment (HHRA) should "consider adequate baseline data and/or modelling of contaminants of potential concern (COPCs) in country foods prior to any project activities" (Health Canada 2010a). A country foods baseline assessment report was completed to fulfill this requirement (Appendix 21-A). The baseline assessment included the use of tolerable daily intake (TDI) values, which are the amount of human exposure to a contaminant that would not be expected to cause health effects, and the estimated daily intakes (EDI) of contaminants were compared to the TDIs to determine the level of risk.

21.2.3 Drinking Water Quality

Provision of services, such as drinking water supply, is regulated in BC. The BC *Drinking Water Protection Act* (2001) and Drinking Water Protection Regulation (BC Reg. 200/2003) are the key legislative requirements supporting the provision of potable drinking water in BC. This legislation applies to all water systems, other than those that supply single family homes[1] or other specifically excluded systems. The *Drinking Water Protection Act* (2001) and Drinking Water Protection Regulation (BC Reg. 200/2003) require that all water systems meet minimum water treatment standards, monitoring type and frequency, and specific water quality standards.

Provincial and federal drinking water quality guidelines (DWQGs) are available to ensure potability of water and protection of human health (Table 21.2-3), however, as guidelines, the DWQGs set by BC MOE for source water quality are not enforceable (BC MOE 2013b).

Table 21.2-3. Provincial and Federal Drinking Water Quality Guidelines

Parameter	BC Drinking Water Quality Guidelines (mg/L) [a]	Canadian Drinking Water Quality Guidelines (mg/L) [b]
Aluminum, dissolved	0.2	-
Antimony	0.014	0.006
Arsenic	0.025	0.01
Barium	-	1
Beryllium	0.004	-
Boron	5	5
Cadmium	-	0.005
Chromium	-	0.05
Copper [c]	0.5	1
Fluoride	1	1.5
Lead	0.05	0.01
Mercury	0.001	0.001
Molybdenum	0.25	-
Nitrate (as N)	10	10
Nitrite (as N)	1	-
Selenium	0.01	0.01
Sulphate	500	-
Thallium	0.002	-
Uranium	-	0.02
Zinc [c]	5	5

Notes:
[a] *BC Drinking Water Quality Guidelines - approved and working (BC MOE 2013h).*
[b] *Guidelines for Canadian Drinking Water Quality Summary Table (Health Canada 2012).*
[c] *Aesthetic guideline.*

---

[1]The BC Groundwater Protection Regulation Ground Water Protection Regulation, B.C. Reg. 299/2004. also applies to private well owners, as does the *Water Act* (1985).

The drinking water assessment also included a review of the *Action Plan for Safe Drinking Water in British Columbia* (BC MHP and BC MHS 2002), which highlights the importance of protecting drinking water from "source to tap." The action plan provides a framework primarily intended to improve or maintain the water quality for water systems that are subject to the *Drinking Water Protection Act*; there are no such systems located within the human health LSA. However, there are a number of community water systems with the RSA (e.g., in Vavenby or Barriere) where source protection is an important component of ensuring compliance with the *Drinking Water Protection Act* (2001) and Drinking Water Protection Regulation (BC Reg. 200/2003).

Where available, and since the Project is located in the province of BC, BC DWQGs will be used in the assessment. Additionally, the Guidelines for Canadian Drinking Water Quality (referred to throughout this chapter as the Canadian DWQGs; Health Canada 2012) may be used as guidelines for parameters where BC DWQGs are lacking.

The Kamloops Land and Resource Management Plan (LRMP; BC ILMB 1995) also has special community watershed zones in the Kamloops LRMP for resource management purposes. One of the primary objectives of these zones is to "maintain community water quality and quantity" (BC ILMB 1995).

21.2.4 Noise

There is currently no federal or provincial legislation that stipulates ambient noise levels for mine development projects in terms of human impacts. The AIR (BC EAO 2011) for the Project required the Application to address noise effects on humans in accordance with Health Canada's *Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise*[2] (Health Canada 2011a). The Health Canada guideline states: "There are reasonable cause-and-effect associations linking noise exposure to hearing loss, sleep disturbance, interference with speech intelligibility, noise complaints and a high level of annoyance" (Health Canada 2011a). Health Canada's advice is based on:

> *…the expected changes between existing and predicted daytime and nighttime sound levels (for construction, operation, and decommissioning activities) at locations where people are or will be present, as well as on the characteristics of the noise (e.g., impulsive or tonal) or the type of community (e.g., urban, suburban, or quiet rural areas)*.

Data and guidelines from the following sources were used in addition to Project-related information to assess noise levels in the study area:

- Health Canada (2010e) *Useful Information for Environmental Assessments* (Section 6: Noise Effects);
- Michaud, Bly, and Keith (2008) *Using a Change in Percent Highly Annoyed with Noise as a Potential Health Effect Measure for Projection Under the Canadian Environmental Assessment Act*;

[2] This document has since been rescinded by Health Canada.

- Standards Australia's AS2187.2-2006™ Explosives—Storage and Use Part 2: Use of Explosives (Appendix J);
- US Environmental Protection Agency (US EPA 1974) *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*;
- US Federal Transit Administration's *Transit Noise and Vibration Impact Assessment* (Harris Miller Miller & Hanson Inc. 2006); and
- WHO (1999) *Guidelines for Community Noise*.

Noise can directly affect human health through psychological and physiological effects. Noise level metrics considered for impact from noise are: sleep disturbance, interference with speech communication, effects from blasting, complaints, and high annoyance (HA). The measures of the potential effects of noise covered in this human health assessment are those recommended by Health Canada (2010e) and are summarized in Table 21.2-4. Noise is typically monitored as a sound pressure level, in A-weighted decibels (dBA). The A-weighting is designed to match the average frequency response of the human ear. Decibels with no weighting applied between 20 Hz to 20 kHz are referred to as dBL.

Table 21.2-4. Project Noise Effects Criteria

Project Metric	Description *Human Receptors (Off Site)*	Criteria
L_d	Daytime noise level for assessing speech interference	55 dBA
L_n	Nighttime noise level for assessing sleep disturbance outside the Project boundary (i.e., outdoors, such as in a campground)	30 dBA
	Nighttime noise level for assessing sleep disturbance outside the Project boundary (i.e., indoors with windows open)	45 dBA [a]
	Nighttime noise level for assessing sleep disturbance inside the Project boundary (i.e., indoors with windows closed)	57 dBA [a]
L_{peak}	Blasting operations lasting longer than 12 months at sensitive site [b]	120 dBL [c]
Δ %HA	No impact on percent highly annoyed due to Project-related road traffic	3 – 5 dBA
	Moderate impact on percent highly annoyed due to Project-related road traffic	5 – 8 dBA
	Severe impact on percent highly annoyed due to Project-related road traffic	>8 dBA

Notes:
[a] *This is an external noise level and assumes that internal noise levels are in the order of 15 dBA lower with open windows and 27 dBA lower with closed windows (which would be the expected normality in the Project's climate). In addition, WHO (1999) recommends that internal sound levels should not exceed approximately 45 dBA (Leq) more than 10 to 15 times per night.*
[b] *A sensitive site includes houses and low rise residential buildings, hospitals, theatres, schools, etc., occupied by people.*
[c] *Unless agreement is reached with occupier that a higher limit may apply.*

In general, a 3 dBA difference is required by the average person to notice any alteration in noise level. Human perception of sound pressure is non-linear: a ten-fold increase in sound pressure is perceived as a doubling of the noise level by the average person.

Noise criteria can be specified based on Project noise levels or the total (baseline plus project) noise levels. For relative criteria—criteria based on the increase in noise from existing conditions such as annoyance—total noise has been used. For absolute criteria—noise criteria that do not change depending on existing conditions—Project noise has been used. This interpretation is consistent with past guidance communicated by Health Canada and avoids the impasse that would otherwise be created if the existing noise already exceeds an absolute criterion.

Health Canada (2010e) recommends evaluating increases in predicted noise levels over baseline conditions for the daytime (L_d) and nighttime (L_n) equivalent noise levels, as well as a whole day equivalent noise level descriptor (L_{dn}). Impulsive and tonal characteristics of source noise can increase potential adverse effects and should also be accounted for. People are often exposed to sounds from more than one source and combinations of health effects are common, such as interference with speech in the day and sleep disturbance at night, thus the total adverse health load of noise must be considered over 24 hours (WHO 1999).

21.3 Scoping the Effects Assessment

21.3.1 Valued Components

The BC EAO defines VCs as components "that are considered important by the proponent, public, First Nations, scientists, and government agencies involved in the assessment process" (BC EAO 2013). To be included in the Application/EIS, there must be a perceived likelihood that the VC will be affected by the proposed Project. VCs proposed for assessment were identified in the AIR (BC EAO 2011) and in the CEA Agency (2011) Background Information document.

This section includes a description of the scoping process used to identify potentially affected VCs and select assessment boundaries. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant effects. Valued Components have the potential to be indirectly affected by changes in the baseline condition of other environmental components, thereby acting as receptors of that change. Indirect effects may, in turn, also affect the baseline condition of the VC. Scoping of VCs for human health relies on selecting the most likely exposure pathways and exposure media through which human health can be affected. These can be direct pathways (i.e., air emissions that are inhaled or Project noise that may affect sleep) or indirect pathways (i.e., food chain effects for country foods). Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

21.3.1.1 Consultation Feedback on Proposed Valued Components

A preliminary list of proposed VCs was drafted early in project planning based on the expected physical works and activities of the reviewable project; type of project being proposed; local area and regions where the proposed project would be located; and consultation with federal, provincial, and local agencies. A summary of how scoping feedback was incorporated into the selection of the potential effects to the human health VC is provided below in Table 21.3-1.

Concerns about potential effects to human health have been raised by Aboriginal groups (Appendix 3-F of Chapter 3) and by government (Appendix 3-G of Chapter 3).

Table 21.3-1. Consultation Feedback on Proposed Valued Component

VC Potential Effects	Feedback by*				Issues Raised	Proponent Response
	AG	G	P/S	O		
Air quality	X				Air quality was identified by the SFN, LSIB and NIB as an issue of concern.	Air quality can have a direct effect on human health, especially sensitive people, therefore air quality was included as a component of the human health assessment.
Country foods quality	X	X			Country foods quality was identified by the SFN, NIB and government as a potential issue.	Consumption of country foods can have a potential direct effect on human health therefore country foods was included as a component of the human health assessment.
Drinking water quality					Although water quality was identified by Aboriginal groups and government as an area of concern, no issues with respect to effects on drinking water and human health were identified.	Water quality can have potential effects to human health through direct and indirect pathways, therefore drinking water quality was included as a component of the human health assessment.
Noise				X	No specific issue was raised in regard to noise effects on human health.	Recommended for inclusion by Health Canada guidance document

**AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder; O = Other*

Simpcw First Nation (SFN) expressed concern regarding the potential for air quality changes as a result of Project activities and infrastructure including effects of airborne dust, dust from waste rock piles affecting air quality in the North Thompson Valley, and effects of contaminated air on the environment in the vicinity of the Project (Appendix 3-F, Chapter 3). Little Shuswap Indian Band (LSIB) also raised concern regarding dust and air-borne particulate matter affecting downstream/ downwind air quality (Appendix 3-F of Chapter 3).

SFN expressed concerns regarding the chemical composition of material in waste rock piles and water in tailings pond that may affect plants, wildlife, birds, fish, insects and/or humans coming in contact with or ingesting it (Appendix 3-F of Chapter 3). SFN also indicated interest in inclusion of local knowledge in country foods and consumption rates in the country foods assessment (Appendix 3-F of Chapter 3). SFN were also concerned with the effects on food procurement areas and fish-bearing waterbodies and potential effects on SFN health and well-being (Appendix 3-F of Chapter 3). SFN also expressed concern regarding impacts on SFNs ability to practise their traditional livelihood with health and well-being, cultural practices and trade networks. Feedback during the AIR review process from the Working Group, in particular Health Canada, the BC Ministry of Environment (MOE), the CEA Agency, and the Interior Health Authority confirmed the inclusion of country foods for the human health VC assessment (Appendix 3-J, Chapter 3).

Although concerns were expressed regarding surface and ground water quality by several Aboriginal groups, government agencies, and general public, no specific concerns about drinking water quality were raised (Appendices 3-C, 3-G, 3-H, 3-F, 3-J, and 3-L, of Chapter 3).

The Neskonlith Indian Band (NIB) stated that noise impacts from operations have the potential to disturb wildlife on and adjacent to the mine site (Appendix 3-F). They were also concerned with impacts of the mine operation on their culture, health and social well-being. The NIB also expressed concern on impacts from operations on vegetation and plant communities, including but not limited to traditional use items such as medicinal, food, ceremonial values on and adjacent to the mine site.

21.3.1.2 Selecting Valued Components

The Health Canada (2010e) *Useful Information for Environmental Assessments* document was used to scope relevant and appropriate components of the human health assessment, which included considering potential effects resulting from:

- changes in air quality;
- changes in country foods quality;
- changes in drinking water quality; and
- changes in noise levels.

To support the final selection of VCs for the effects assessment, Project components and activities associated with each phase of the Project were screened to identify whether the Project has the potential to interact with human health via air quality, country foods, drinking water, and noise pathways. A list of key Project components and activities developed from the Project's Technical Report and Feasibility Study (Appendix 5-A) was used to evaluate potential interactions between the Project and human health, presented in Table 21.3-2.

Changes in Air Quality

Project components have the potential to affect air quality and consequently human health. Emissions from stacks (e.g., incinerator) and fugitive dust sources (e.g., from stockpiles, access roads) will result in emissions of criteria air contaminants (i.e., particulate matter) which may affect local air quality. Effects on human health due to changes in air quality will be assessed by analyzing changes in concentrations of PM_{10} (suspended particulates with diameter less than 10 µm) and $PM_{2.5}$. Project components related to surface water management, procurement of goods and labour, or monitoring activities are not expected to affect air quality.

Changes in Country Foods Quality

The majority of Project components and activities have the potential to affect the quality of country foods with the exception of monitoring activities and procurement of goods and labour. The concentration of most metals and trace elements in humans is largely attributable to the ingestion of food (e.g., moose, fish, and berries) followed by the ingestion of water and inhalation of metals in air contributing to a lesser extent. Because of the potential for interaction (Table 21.3-2) and because country foods were of interest to the SFN (being traditionally gathered in the regional study area [RSA]), changes (i.e., potential for degradation) in the quality of country foods was incorporated into the effects assessment.

Table 21.3-2. Interaction of Project Components and Activities with Proposed Human Health Valued Components

Category	Project Components and Activities	Air Quality	Country Foods Quality	Drinking Water Quality	Noise
Construction					
Concrete production	Concrete batch plant installation, operation and decommissioning	X	X		X
Dangerous goods and hazardous materials	Hazardous materials storage, transport, and off-site disposal	X	X		X
	Spills and emergency management				
Environmental management and monitoring	Construction of fish habitat offsetting sites	X	X	X	X
Equipment	On-site equipment and vehicle use: heavy machinery and trucks	X	X		X
Explosives	Explosives storage and use	X	X	X	X
Fuel supply, storage and distribution	Fuel supply, storage and distribution	X	X		X
Open pit	Open pit development - drilling, blasting, hauling and dumping	X	X	X	X
Potable water supply	Process and potable water supply, distribution and storage				
Power supply	Auxiliary electricity - diesel generators	X	X		X
	Power line and site distribution line construction: vegetation clearing, access, poles, conductors, tie-in	X	X	X	X
Processing	Plant construction: mill building, mill feed conveyor, truck shop, warehouse, substation and pipelines	X	X	X	X
	Primary crusher and overland feed conveyor installation	X	X		X
Procurement and labour	Employment and labour				
	Procurement of goods and services				
Project Site development	Aggregate sources/ borrow sites: drilling, blasting, extraction, hauling, crushing	X	X	X	X
	Clearing vegetation, stripping and stockpiling topsoil and overburden, soil salvage handling and storage	X	X	X	X
Project Site development	Earth moving: excavation, drilling, grading, trenching, backfilling	X	X	X	X
Rail load-out facility	Rail load-out facility upgrade and site preparation	X	X	X	X
Roads	New TMF access road construction: widening, clearing, earth moving, culvert installation using non-PAG material	X	X	X	X
	Road upgrades, maintenance and use: haul and access roads	X	X	X	X
Stockpiles	Coarse ore stockpile construction	X	X	X	X
	Non-PAG Waste Rock Stockpile construction	X	X	X	X
	PAG and Non-PAG Low-grade ore stockpiles foundation construction	X	X	X	X
	PAG Waste Rock stockpiles foundation construction	X	X	X	X
Tailings management	Coffer dam and South TMF embankment construction	X	X	X	X
	Tailings distribution system construction	X	X	X	X
Temporary construction camp	Construction camp construction, operation, and decommissioning	X	X	X	X
Traffic	Traffic delivering equipment, materials and personnel to site	X	X	X	X
Waste disposal	Waste management: garbage, incinerator and sewage waste facilities	X	X	X	X
Water management	Ditches, sumps, pipelines, pump systems, reclaim system and snow clearing/stockpiling	X	X		X
	Water management pond, sediment pond, diversion channels and collection channels construction	X	X	X	X
Operations 1					
Concentrate transport	Concentrate transport by road from mine to rail loadout	X	X		X
Dangerous goods and hazardous materials	Explosives storage and use	X	X	X	X
	Hazardous materials storage, transport, and off-site disposal	X	X		X
	Spills and emergency management				
Environmental management and monitoring	Fish habitat offsetting site monitoring and maintenance		X	X	
Equipment fleet	Mine site mobile equipment (excluding mining fleet) and vehicle use	X	X		X
Fuel supply, storage and distribution	Fuel storage and distribution	X	X		X
Mining	Mine pit operations: blast, shovel and haul	X	X	X	X
Ore processing	Ore crushing, milling, conveyance and processing	X	X	X	X
Potable water supply	Process and potable water supply, distribution and storage				
Power supply	Backup diesel generators				
	Electrical power distribution				
Processing	Plant operation: mill building, truck shop, warehouse and pipelines	X	X		X
Procurement and labour	Employment and labour				
	Procurement of goods and services				
Rail load-out facility	Rail-load out activity (loading of concentrate; movement of rail cars on siding)	X	X		X
Reclamation and decommissioning	Progressive mine reclamation	X	X	X	X
Stockpiles	Construction of Non-PAG tailings beaches	X	X	X	X
	Construction of PAG and Non-PAG Low Grade Ore Stockpile	X	X	X	X
	Non-PAG Waste Rock Stockpiling	X	X	X	X
	Overburden stockpiling	X	X	X	X
Tailings management	Reclaim barge and pumping from TMF to Plant Site		X	X	
	South TMF embankment construction	X	X	X	X
	Sub-aqueous deposition of PAG waste rock into TMF		X	X	
	Tailings transport and storage in TMF		X	X	
	Treatment and recycling of supernatant TMF water		X	X	
Traffic	Traffic delivering equipment, materials and personnel to site	X	X		X
Waste disposal	Waste management: garbage and sewage waste facilities	X	X	X	X
Water management	Monitoring and maintenance of mine drainage and seepage		X	X	
	Surface water management and diversions systems including snow stockpiling/clearing				
Operations 2	***Includes the Operations 1 non-mining Project Components and Activities, with the addition of these activities:***				
Processing	Low grade ore crushing, milling and processing	X	X	X	X
Reclamation and decommissioning	Partial reclamation of Non-PAG waste rock stockpile	X	X	X	X
	Partial reclamation of TMF tailings beaches and embankments	X	X	X	X
Tailings management	Construction of North TMF embankment and beach	X	X	X	X
	Deposit of low grade ore tailings into open pit	X	X	X	X
Water management	Surface water management				
Closure					
Environmental management and monitoring	Environmental monitoring including surface and groundwater monitoring				
	Monitoring and maintenance of mine drainage, seepage, and discharge		X	X	
	Reclamation monitoring and maintenance		X	X	
Open pit	Filling of open pit with water and storage of water as a pit lake		X	X	
Procurement and labour	Employment and labour				
	Procurement of goods and services				
Reclamation and decommissioning	Decommissioning of rail concentrate loadout area		X	X	
	Partial decommissioning and reclamation of mine site roads	X	X	X	X
	Decommissioning and removal of plant site, processing plant and mill, substation, conveyor, primary crusher, and ancillary infrastructure (e.g., explosives facility, truck shop)	X	X	X	X
	Decommissioning of diversion channels and distribution pipelines	X	X	X	X
	Decommissioning of reclaim barge				
	Reclamation of Non-PAG LGO stockpile, overburden stockpile and Non-PAG waste rock stockpile	X	X	X	X
	Reclamation of TMF embankments and beaches	X	X	X	X
	Removal of contaminated soil	X	X	X	X
	Use of topsoil for reclamation	X	X	X	X
Stockpiles	Storage of waste rock in the non-PAG waste rock stockpile	X	X	X	X
Tailings management	Construction and activation of TMF closure spillway		X	X	X
	Maintenance and monitoring of TMF		X	X	
	Storage of water in the TMF and groundwater seepage		X	X	
	Sub-aqueous tailing and waste rock storage in TMF		X	X	
	TMF discharge to T-Creek		X	X	
Waste disposal	Solid waste management	X	X		X
Post-Closure					
Environmental management and monitoring	Environmental monitoring including surface and groundwater monitoring				
	Monitoring and maintenance of mine drainage, seepage, and discharge		X	X	
	Reclamation monitoring and maintenance		X	X	
Open pit	Construction of emergency spillway on open pit		X	X	
	Storage of water as a pit lake		X	X	
Procurement and labour	Procurement of goods and services				
Stockpiles	Storage of waste rock in the non-PAG waste rock stockpile		X	X	
Tailings management	Storage of water in the TMF and groundwater seepage		X	X	
	Sub-aqueous tailing and waste rock storage		X	X	
	TMF discharge		X	X	

Note: a column is marked with an X when it has been determined that the Project component or activity could potentially interact with the VC.

Changes in Drinking Water Quality

Water quality is an essential component of the ecosystem and is linked to human health directly via ingestion or indirectly through the food web (e.g., vegetation, fish, and wildlife). Drinking water may be obtained from either surface or groundwater sources, although in undeveloped areas surface water sources are more commonly used since they are more readily accessible. There are also several domestic groundwater wells in the human health RSA (e.g., along Baker Creek). Human health can be affected by chemical (e.g., ions, metals) and bacteriological constituents that may be present in untreated, naturally-occurring surface waters. Construction of ore and waste rock stockpiles and TMF discharge may affect local surface water quality. Effects on human health due to changes in drinking water quality will be assessed by comparing predicted water concentrations to drinking water quality guidelines. The indicators for drinking water quality are: concentrations of total and dissolved metals, nutrients, and ions (e.g., fluoride). Project components related to rail load-out, procurement of goods and labour, or auxiliary electricity are not expected to affect drinking water quality.

Changes in Noise Levels

Changes in noise levels have the potential to affect human health and well-being for local residents, Aboriginal users in the area, and employees in off-work hours. The Construction, Operations, Closure, and Post-Closure phases of the Project will emit noise from many sources, including blasting and excavating waste rock from the open pit and hauling, processing ore at the Plant Site, and road upgrades, maintenance, and use. Closure and Post-Closure noise levels will be lower, intermittent, and related primarily to reclamation and maintenance activities (Table 21.3-2). Project components related to surface water management, spills and emergency management, or procurement of goods and labour are not expected to affect noise levels. Although noise was not raised as a human health concern, in keeping with best practise and as recommended by Health Canada, a noise assessment was undertaken. Effects on sleep disturbance, interference with speech communication, human discomfort from blasting, and high annoyance were assessed.

The potential effects selected for inclusion in the assessment for the human health VC are presented in Table 21.3-3. This list was presented to the EA Working Group for discussion on September 17, 2014.

Table 21.3-3. Valued Components Selected for Assessment

Assessment Category	Subject Area	Valued Components	Potential Effects
Health	Health	Human health	Changes in: Air quality Country foods quality Drinking water quality Noise

21.3.2 Defining Assessment Boundaries

Assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the areas and times during which the Project is expected to interact with human health, as well as the constraints that may be placed on the assessment due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part in scoping for human health, and encompasses possible direct, indirect, and induced effects of the Project on human health.

21.3.2.1 Temporal Boundaries

Temporal boundaries are the time periods considered in the assessment for various Project phases and activities. Temporal boundaries reflect those periods during which planned Project activities are reasonably expected to potentially affect human health. Potential effects will be considered for each phase of the Project as described in Table 21.3-4.

Table 21.3-4. Temporal Boundaries used in the Human Health Assessment

Phase	Project Year	Length of Phase	Description of Activities
Construction	-2 and -1	2 years	Pre-construction and construction activities.
Operations 1	1 - 23	23 years	Active mining in the open pit from year 1 through to year 23.
Operations 2	24 - 28	5 years	Low-grade ore processing from the end of active mining through to the end of year 28.
Closure	29 – 35	7 years	Active closure and reclamation activities while the open pit and TMF are filling.
Post-Closure	36 onwards	50 years	Steady-state long-term closure condition following active closure, with ongoing monitoring.

All of the Project phases could potentially interact with air quality; however, a 12-month period representative of conditions during the peak of the Construction and Operations phases were included in the air quality modelling since the majority of emissions will occur during these phases. By determining the effects of the years with the highest emissions, it can be assumed that if the effects during these years are found to be not significant, the potential effect for the entirety of the Project should also be not significant. It is anticipated that emission sources during Closure and Post-Closure phases will be significantly lower than those during Construction and Operations.

The potential for effects to human health from drinking water was assessed for all phases of the Project, based on the results of the water quality predictive model (Chapter 13, Appendix 13-C).

Potential effects on noise levels were considered for peak periods during the Construction and Operations phases of the Project when activity levels are at their maximum, thus generating the most noise (Section 10.5.1). If the effects of noise are found to be not significant during these peak periods, effects from noise during other periods should be even less. Each of the temporal boundaries has been chosen for having the highest intensity of significant noise-generating equipment and operations across the Project area, therefore representing the highest potential for noise emission.

21.3.2.2 Spatial Boundaries

Project Site

The Project footprint consists of the mine site with a defined buffer of 500 m around the primary Project components, and also includes linear facilities. Mine site components include the open pit;

the open pit haul road, primary crusher, and ore conveyor; mill plant site with ore processing facilities and intake/outtake pipelines; TMF; overburden, topsoil, PAG waste rock, and non-PAG waste rock stockpiles; and non-PAG and PAG low-grade ore stockpiles.

Local Study Area

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 as a zone of influence to account for potential effects of Project-related activities (e.g., dust deposition). In addition, other physical features such as waterways were used to define the study areas, when they were considered likely to be the limit of the potential future effects of the Project.

The human health local study area (LSA) incorporates the Project footprint (Project Site and infrastructure) and surrounding area within which there is a reasonable potential for immediate direct and indirect effects on human health due to an interaction with Project components or activities (Figure 21.3-1). The selection of the human health LSA took into account the LSAs used by other VCs (e.g., air quality, country foods [wildlife], surface water quality, and noise) with a pathway to human health. The boundaries of the human health LSA were based on a combination of the surface water quality LSA (Figure 13.3-1), which includes watersheds that could be potentially indirectly or directly affected by mine development and operation, and the wildlife LSA (Figure 16.3-1), which encompasses an area extending at least 1 km on all sites of the Project Site. No LSA was defined for the assessment of potential noise effects on human health.

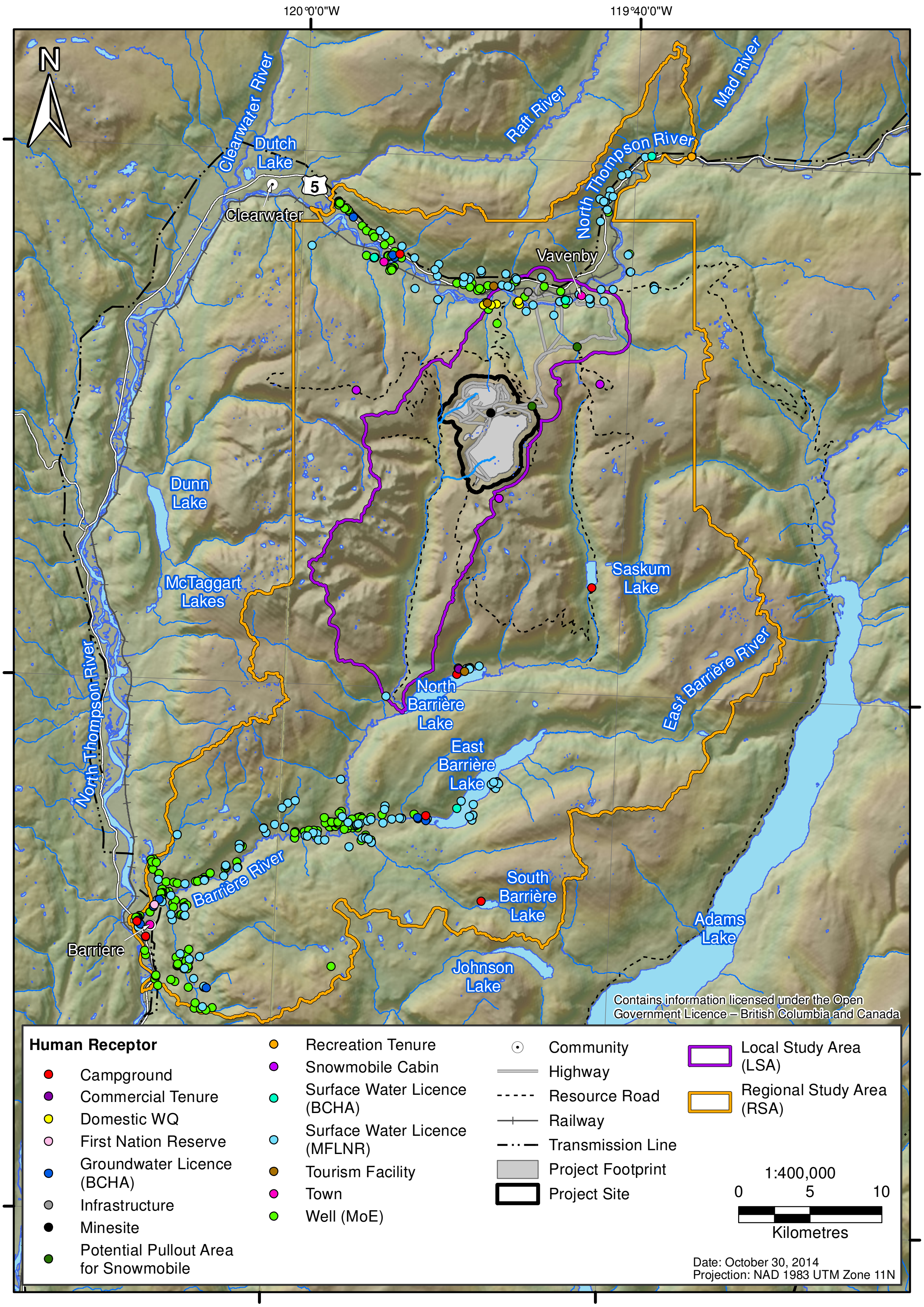
Regional Study Area

The human health RSA is the spatial area within which there is potential for direct and indirect interaction and/or cumulative effects to occur (Figure 21.3-1). The selection of the human health RSA took into account the RSAs used by other VCs (e.g., surface water quality, air quality, country foods [wildlife], and noise) that have the potential to affect human health.

The human health RSA incorporates the outer boundaries formed by the overlay of the air quality modelling domain (Figure 9.3-1), the surface water quality RSA (Figure 13.3-1), and the wildlife RSA (Figure 16.3-2). The air quality modelling domain is the expected zone of influence within which there is a reasonable potential for immediate direct and indirect effects on air quality as a result of the Project. The air quality model domain is a large rectangle centred on the proposed Project and extends 10 km on either side of the Project Site. The surface water RSA includes the Barrière River watershed to its mouth and the North Thompson River watershed to Birch Island, and is intended to encompass an area beyond which effects of the Project would not be expected. The wildlife RSA boundary consisted of the Vavenby and Barriere Landscape Units and a broader area where there is potential for interaction of the proposed Project with past, present, and future activities that might result in cumulative adverse effects on wildlife. The Vavenby and Barriere Landscape Units are based on provincially defined areas used for planning and management of biodiversity, old growth forest retention, wildlife habitat maintenance, and timber harvesting. Other ecological factors, such as height of land, were also considered when delineating boundaries.

Figure 21.3-1

Human Receptor Locations within the Human Health Regional and Local Study Areas



Noise

The RSA for noise was established based on the zone of influence beyond which the residual effects of the Project are expected to diminish to a negligible state. The zone of influence was established based on the noise monitoring baseline study undertaken for the Project (Appendix 10-A), prior project experience, and technical expertise. Project-related noise may be audible under calm conditions at a distance of up to 10 km from the source (Golder Associates Ltd. 2002). As such, the noise RSA (Chapter 10, Figure 10.3-1) was defined to include a zone extending 10 km around the Project Site. This area was selected so that noise contours could be predicted to levels 5 to 10 dB below the relevant criteria limits.

21.3.2.3 Administrative and Technical Boundaries

No administrative boundaries apply to the human health effects assessment. First Nations (i.e., Simpcw First Nation), hunters, and trappers were assumed to hunt, trap, fish, and collect country foods throughout the LSA and RSA and were not constrained by administrative boundaries.

Human receptor locations influenced the assessment boundaries for human health because in order for there to be effects to human health, humans must be present and be exposed to the contaminants or noise (see Section 21.1). Human receptor locations included permanent or temporary locations (e.g., campgrounds, cabins, snowmobile pullout areas, First Nation reserves, tourism facilities, the temporary construction workers' camp, houses in Vavenby, Barriere, and Birch Island) identified in Chapter 18, Land and Resource Use Effects Assessment; Chapter 17, Socio-economics Effects Assessment; as well as domestic wells and domestic surface water licences listed by the BC Health Authority (BC HA), the BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO), and the British Columbia Ministry of Environment (BC MOE). A list of 488 human receptors included in the RSA is provided in Appendix 21-B. As some receptors had multiple features (e.g., a resort with a surface water license and campground), the number of human receptors is over-estimated.

Country Foods

The country foods assessment assumes that land users (e.g., First Nation and non-First Nation hunters, trappers, and recreationists) consume country foods harvested from anywhere inside the RSA, thus there are no specific receptor locations. Sixteen registered trap lines overlap the RSA and three of these overlap the LSA. Trapped species include marten (TR337T001) and weasel (TR0341T003), as well as squirrel and beaver. Larger species trapped within the RSA include bobcat, lynx, coyote, and wolverine (HCMC 2013).

The country foods assessment boundaries during the life of the Project are the same as the baseline (i.e., the country foods LSA and RSA; see Appendix 21-A). To provide a conservative estimate of human exposure to COPCs from country foods, it is assumed that 100% of the consumed country foods were collected or hunted from within the RSA. Potential receptors for country foods are adult land users and toddlers (the most sensitive receptor).

It is recognized that the social, cultural, spiritual, nutritional, and economic benefits of country foods together play a role in how harvesters perceive country foods. This perspective of health and well-being cannot be assessed in the same quantitative manner as in the baseline country foods report, which is a science-based approach recommended by Health Canada to protect human receptors from adverse health effects caused by exposure to the selected COPCs. Risk perception will be discussed qualitatively in Section 21.5.2.2.

Drinking Water

The drinking water assessment assumes that land users (e.g., First Nation and non-First Nation hunters, trappers, and recreationists) may drink surface water from streams anywhere inside the RSA, which may or may not be treated for chemical contaminants (i.e., metals), dependent on the preferred practice of the land user. Domestic groundwater wells and locations of domestic surface water licences are also used for drinking water within the RSA and were included in this assessment (Figure 21.3-1).

Noise

Noise levels in the workplace are regulated by WorkSafe BC, which stipulates an employee exposure threshold of less than 85 dBA for L_{ex} (average noise exposure based on a length of time) daily noise exposure level and 140 dBC peak sound level during work hours (WorkSafe BC 2014). The *Health, Safety and Reclamation Code for Mines in British Columbia* (BC MEMPR 2008) also limits the maximum permissible noise exposure for unprotected ears on a daily basis to be 85 dBA L_{ex} average for 8-hours or equivalent, with no exposure to steady state noise over 108 dBA and no exposure to peak impulse noise over 140 dBA.

During the Construction Phase, activities are expected to occur for 70 hours per week. It was assumed these activities will take place only during the daytime (7:00 a.m. to 10:00 p.m.), with no activity at nighttime (Chapter 10, Noise Effects Assessment). Since the *Health, Safety and Reclamation Code for Mines in British Columbia* (BC MEMPR 2008) and WorkSafe BC (2014) requirements are in effect during the daytime and there is no activity at night, there is no potential for noise to affect employee health during the Construction Phase. Off-duty employees that are off site will be considered in this assessment during the Operations phase.

Road traffic noise tends to have a greater effect on those receptors in the immediate vicinity (within 50 m) of the roadway. Additionally, given that there is existing road traffic through Vavenby, the scope of this assessment is to quantify the increase in noise level attributable to the Project—namely along the following roads upon which the majority of Project-related traffic will travel: McCorvie Road (nearest receptor is 13 m from road edge), Vavenby Road (nearest receptor is 13 m from road edge), and Capostinsky Road (nearest receptor is 20 m from road edge).

21.4 BASELINE CONDITIONS

Baseline studies for VCs with pathways to human health (air quality, surface water quality, country foods and noise) were initiated to characterize existing environmental conditions prior to Project commencement. Table 21.4-1 provides an overview of the baseline studies and years of available data.

Table 21.4-1. Summary of Baseline Studies for the Project

Subject Area	Field Baseline Studies	Years of Available Data
Atmospheric environment	Air quality	2011 to 2014
	Noise	2012
Freshwater environment	Water quality	2007 to 2014
	Hydrogeology	2010 to 2014
Human environment	Country foods soil data	2012
	Country foods vegetation data (huckleberry leaves and berries, Sitka valerian, willow, fireweed, and sorbus)	2012
	Country foods fish data (Rainbow Trout and Bull Trout)	2011 to 2012
	Country foods small terrestrial mammal data	2012

21.4.1 Regional and Historical Setting

To present a regional overview for human health, reports from health agencies, peer-reviewed studies, and surveys were reviewed. The emphasis of the regional overview is placed on the physical determinants of health (e.g., environmental, toxicological) and human receptor locations.

Several historical and current human activities are within close proximity to the proposed Project Site. These include forestry, cattle-based agriculture, recreational land use (e.g., snowmobiling) and water use, and hunting, trapping, and fishing. The communities of Barriere, Clearwater, Birch Island, and Vavenby are located in the RSA.

The Project is situated in the Kamloops Timber Supply Area within the Kamloops Forest District. There are 12 active cutblock tenures in the LSA (Figure 18.4-6), held by seven different entities, although activity within the sector has declined, as it has across the province over the past decade. The human health LSA is relatively sparsely forested and has been harvested previously.

Due to a lack of arable land and the short frost-free period annually, the majority of agricultural properties are ranches and farming in the area north of the community of Clearwater, outside of the human health RSA, where soil conditions are better. Range Tenures exist throughout the region (see Chapter 18, Figure 18.4-9 and 18.4-10), and one Range Tenure (RAN077435) belonging to Mitchell Cattle Co. falls directly within the Project Site.

There are no Provincial Parks within the human health LSA or RSA. The Dunn Peak Protected Area is within the human health LSA and RSA (Figure 18.4-13) and is managed by BC Parks and subject to the Management Direction Statement for Dunn Peak Park. Dunn Peak Trail is a popular 7.5-km-long hiking trail that leads to the base of Dunn Peak. Access to Dunn Peak Protected Area is by ferry and road from Little Fort on the Southern Yellowhead Highway (Highway 5), or by logging road in the Harper Valley from Barriere and North Barrière Lake. Dunn Peak is a wilderness area and there are no roads in the park.

Freshwater fishing, backcountry tourism, boating, swimming, water-skiing, and traversing along waterbodies and drainages are popular within the RSA. There are four recreation sites (Saskum

Lake, North Barrière Lake, East Barrière Lake, and South Barrière Lake) offering a variety of facilities and activities. There are also several recreation trails managed by Recreational Sites and Trails BC (BC MFLNRO 2013).

There are no identified specific uses of Jones, Baker, Chuck, Avery, or Harper creeks within the LSA for recreational purposes. There are no guide outfitting licensed areas in the LSA or RSA.

There are currently three commercial recreation tenures with some portion overlapping the RSA (see Chapter 18, Figure 18.4-14). These comprise one guided freshwater recreation licence, one snowmobile licence, and one multiple use licence on the North Thompson River.

Lakes within the RSA generally start to freeze over in late October and therefore have limited use beyond this time (e.g., for fishing). All streams that are valued for fishing are closed to fishing until July 1 (July 16 for the Clearwater and North Thompson rivers). High water conditions limit access at the start, but access rapidly improves as water levels drop. Adams River (east of the human health RSA) and Raft River (north of the human health RSA) trout follow sockeye in late August and early September. Stakeholders interviewed in 2014 were not aware of fishing on rivers, creeks, or streams located within the LSA (M. Schmidt, pers. comm.). However, the SFN use Harper Creek (specific locations along Harper Creek were not indicated but it is expected that the majority of fishing is conducted below the falls, which is a natural barrier to fish) and the Saskum Lake/Barrière River corridor for fishing. No information was provided on the use of other waterways associated with the Project (i.e., P Creek, T Creek, Baker Creek, or Jones Creek) specifically for fishing.

A number of recreation clubs are located in local communities that facilitate recreation/outdoor experiences, and provide recreational facilities to area families including cross-country skiing, snowmobiling, hiking, and motorcycling. These organizations use existing Forest Service Roads (FSRs; e.g., the Jones Creek and Vavenby Mountain FSRs) to access remote wilderness areas. The use of all-terrain vehicles and snowmobiles are popular recreational pursuits for residents in the region. In addition, Vavenby Trail Rides conducts guided horseback rides on their working cattle ranch near Vavenby on the south side of the North Thompson River from spring until late fall (Vavenby Trail Rides 2014).

The Serenity Performing Arts Centre is located between Birch Island and Vavenby, near the entrance to the Jones Creek FSR within the LSA. The Serenity Performing Arts Centre draws visitors from the surrounding areas, and has capacity for 400 individuals. The centre also operates a campsite nearby with 20 to 30 sites.

Non-resident hunting is a large commercial industry in BC and is governed by the BC *Wildlife Act* (1996). Non-resident hunters may hunt big game only when accompanied by a guide licensed under the *Wildlife Act* (1996), or a person who holds a permit under Section 70 (1) (a) of the Act allowing him or her to accompany the hunter. Non-resident hunting is typically facilitated through a guide outfitter who holds tenure in a registered guiding territory. There are no guide outfitting licences within the human health LSA or RSA to support non-resident hunting.

The Project is located within the Thompson Fish and Wildlife Region 3, which includes several Wildlife Management Units. Big game in Region 3 includes black bear, caribou, cougar, elk, goat, grizzly bear, moose, mule deer, bighorn sheep, white-tailed deer, and wolf. Caribou, elk, bighorn sheep, and goats are not hunted in the RSA or LSA (M. Schmidt, pers. comm.). Mountain goats have been observed near Harper Creek and drainages to the east, such as Saskum Creek. Small game in Region 3 includes weasels, wolverine, fisher, marten, snowshoe hare, blue grouse, spruce grouse, ruffed grouse, coyote, bobcat, and lynx. Fowl hunted in the area includes mostly upland birds such as grouse (blue, spruce, and ruffed; M. Schmidt, pers. comm.). Some hunting of waterfowl (ducks and geese) occurs along the North Thompson River. Hunting is primarily conducted for subsistence, and focuses on mule deer, white-tailed deer, and moose. Stakeholders interviewed in 2014 estimate on an annual basis that several hundred people access the RSA for hunting purposes, but there is a lack of information to determine hunting areas. All-terrain vehicles are commonly used for hunting purposes to access backcountry locations.

Trapping is part of BC's rural economy, pursued primarily to obtain pelts from small fur-bearing animals (marten, weasel, squirrel, beaver, bobcat, lynx, coyote, and wolverine) and in some cases the animal may be used as a subsistence source. Trappers are required to obtain licences covering a prescribed geographic area and submit for approval a fur management plan that outlines the managing and trapping of fur-bearing animals in the licensed area. There are five trapline tenures overlapping the land use LSA (three of these overlap the Project Site), and an additional 11 are located within the land use RSA (see Chapter 18, Figure 18.4-17).

There are two archaeological rock cairns, as well as historic trails and culturally modified trees within the Project Site (Terra Archaeology 2012). However, these archaeological sites were not included in the human health assessment because people do not live there currently.

There are also several past and present projects within the human health RSA. The Weyerhaeuser Sawmill operated between 1965 and 2003, and the Louis Creek Sawmill operated until it was destroyed by a forest fire in 2003 (unknown start date), both sawmills have no plans for resuming operation. The Vavenby Sawmill currently operates in the town of Vavenby (unknown start date) and processes approximately 13% of the annual cut in the Kamloops Timber Supply Area. The Barriere Sawmill started operations in 1968 in the town of Barriere processing cedar and it is still operating.

Although minor, several of the historical or current activities listed above have the potential to affect environmental quality (i.e., noise levels or air, water, soil, and vegetation quality), which can in turn affect human health. The legacy contribution of these historical and current activities to environmental quality has been captured during baseline studies undertaken for the proposed Project.

Air Quality

The air quality at the Project Site is mainly unaffected by anthropogenic sources, reflecting the Project's remoteness. There are a number of anthropogenic sources of CACs within the region, including the town of Vavenby; however, due to the localized nature of anthropogenic air emissions the air quality in the region is considered to be good.

Country Foods

Hunting, trapping, fishing, plant collection, cultural events, and recreational activities are common activities among First Nations, residents, and guided commercial recreation operators near the Project (see Chapters 17, 18, 20, and 22). The existing Highway 5 and a network of logging roads provide relatively easy access to the region.

Historical and current harvest of country foods for traditional purposes within the human health LSA and RSA has been noted for the SFN (2012) and for citizens of the Métis Nation British Columbia (MNBC; ERM Rescan 2014b); however, information on country foods harvested by other First Nations (e.g., Adams Lake Indian Band [ALIB], NIB and LSIB) was unavailable at the time of writing. Traditionally, the SFN harvested several wildlife species for meat, including caribou, moose, elk, bighorn sheep, deer, porcupine, marmot, grouse, waterfowl, and occasionally grizzly bear, black bear, and mountain goat (Appendix 22-A).

Hunting clubs and guide-outfitter businesses are located in the area and hunting takes place during most months of the year (M. Schmidt, pers. comm.). All-terrain vehicles are commonly used for hunting purposes in the RSA to access backcountry locations (ERM Rescan 2014a). An interview with a member of the North Thompson Fish and Game Club indicated that the terrestrial species hunted for consumption in the country foods RSA include deer, moose, grouse, and incidental geese/ducks (North Thompson Fish and Game Club 2014).

The Thompson-Nicola region of BC has a range of lakes and rivers that support a variety of fish species including Bull Trout (*Salvelinus confluentus*), Coho Salmon (*Oncorhynchus kisutch*), Rainbow Trout (*O. mykiss*), Dolly Varden (*S. malma*), and Mountain Whitefish (*Prosopium williamsoni*; Knight Piésold Ltd. 2013). As such, fishing and angling are popular local activities in the region. Fish species caught for consumption include Rainbow Trout, Bull Trout, and Dolly Varden (North Thompson Fish and Game Club 2014). The headwater streams within the Project Site are not fish-bearing, although runoff from these streams flows into fish-bearing waters in upper Harper Creek (lowermost T Creek and P Creek), lower Baker Creek, and lower Jones Creek (Knight Piésold Ltd. 2013). Harper Creek is used by the SFN for fishing purposes (likely below the falls). Recreational fishing locations within the country foods RSA include Saskum, North Barrière, East Barrière, and South Barrière lakes (ERM Rescan 2014a).

Berry picking (i.e., Saskatoon berries, soapberries, huckleberries, blueberries, strawberries, currents, chokecherries, gooseberries, and raspberries) and medicinal plant collection (e.g., arnica, devil's club, juniper) are also important subsistence and cultural activities by SFN members (Appendix 22-A). The human health LSA is not productive for berries, but species that do grow in the area are huckleberry and blueberry (S. Sharpe, pers. comm.).

<u>Drinking Water</u>

There are several water licences within the Human Health LSA and RSA, shown in Figure 21.3-1. Licences to use surface water are administered by the Water Stewardship Division of the BC MOE (2013d) and BC MFLNRO. Water from water licences may be used for a variety of industrial, commercial, and domestic purposes. There are no known residents who draw surface water for drinking (domestic use) from within the immediate area around the Project but there are several in the LSA along the North Thompson River and many more within the RSA, especially along the Barrière River (Figure 21.3-1).

Surface water may be used as drinking water by local people and First Nations members, including water licence holders, trappers, hunters, country food gatherers, and recreational users who consume surface water during backcountry trips. It should be emphasized that no surface water can be considered safe for human consumption without treatment (Health Canada 2008).

Groundwater may also be used for drinking water. The BC Health Authority provides information on drinking water wells used to supply water systems regulated by the *Drinking Water Protection Act* (2001; Data BC 2014). Within the Human Health RSA there are 212 domestic wells and 13 groundwater licences (Figure 21.3-1, Appendix 21-B).

Noise

Potential noise sources in the surrounding area include the unincorporated municipality of Vavenby, located approximately 10 km to the northwest of the Project Site. There is a lumber mill in Vavenby, as well as active logging in the area surrounding the Project Site, with a network of FSRs. Highway 5 runs along the North Thompson River and at its closest point is approximately 7 km to the north of the Project Site. Highway 5 is a significant source of noise in the area due to traffic.

21.4.2 Baseline Studies

21.4.2.1 Air Quality

Objective

The objectives of the air quality baseline monitoring studies were to:

- provide understanding of existing baseline conditions in the vicinity of the Project;
- provide a benchmark for evaluating the potential future effects of the Project; and
- support predictive modelling for effect analysis.

Data Sources

Because of its remoteness, there are limited background air quality data for the area. Project-specific air quality monitoring has therefore been restricted to passive dustfall monitors. In the absence of site-specific monitoring data for other pollutants, the BC Modelling Guideline (BC MOE 2008) recommends that other monitoring data from similar sources and meteorology be used.

As such, the existing air quality across the study area has been determined from available monitoring data from representative stations and a literature review of other air quality studies in the area. No existing air quality studies were identified applicable to the Project Site. The closest airshed management planning study is the Kamloops Airshed Management Plan (City of Kamloops 2012).

Methods

The baseline monitoring program was conducted by Knight Piésold Ltd. from October 2011 to November 2013. Methods employed for the baseline air quality monitoring program are detailed in Appendix 9-A. Figure 3.2-1 of Appendix 9-A indicates the location of the six baseline dustfall monitoring stations. The dominant wind direction was taken into consideration when selecting the site locations. The six dustfall sample containers collected dust for approximately 30 days, after which they were sent to the laboratory for analysis.

Baseline Study Area

The air quality baseline study area is shown in Appendix 9-A, Figure 1.6-1. The air quality LSA encompasses the Project Site and a 10-km buffer, and the air quality RSA extends 50 km from the Project Site. The baseline monitoring program focused on:

- the Project Site, since it is anticipated to be the main location of site activity and air emissions during the Operations phase of the Project, and
- the closest receptor locations, including the towns of Vavenby and Birch Island (a small community on both sides of the North Thompson River located between Clearwater and Vavenby).

Sampling/Monitoring/Assessment

Baseline monitoring began in September 2011 and included dustfall measurements that were collected at six locations: three sites located in Vavenby and three sites located in the Project Site. In 2012, an additional site was installed at Birch Island and a site at Vavenby was deactivated. Baseline air quality was monitored from 2011 to 2013 (Appendix 9-A), with monitoring occurring for two months in 2011, four months in 2012, and three months in 2013; a full year of data is not available. Based on the limited dataset, seasonal or annual change in deposition values could not be assessed.

Since Site DF-01 (as indicated in Figure 3.2-1 of Appendix 9-A) was not established in accordance with sampling method ASTM D1739-98, the results are less reliable than those from the other sites; however, it is believed that these samples will still provide a representative average of daily dustfall levels for the location sampled.

In a number of cases the containers were exposed for longer than the recommended time period. The March and August 2012 samples were exposed for two months, rather than the recommended 30-day period, and the January and June 2012 samples were exposed for approximately three months. It is not anticipated that any appreciable degradation of the sample would have occurred during this short time period; however, there is the potential for canisters to fill up with rain water and overflow, or become damaged. The containers were checked when collected and no evidence was found to suggest the containers were not suitable for analysis.

Concentrations of PM_{10} and $PM_{2.5}$ were not collected as part of the baseline monitoring program and information on natural background levels of particulate matter in Canada is limited as urban centres are the focus of monitoring programs (BC MWLAP and Environment Canada 2003). Thus, the mean PM_{10} and $PM_{2.5}$ concentrations from a study that investigated air quality at six remote rural locations in Alberta (Cheng et al. 2000) were used as comparative background values for the Project.

21.4.2.2 Quality of Country Foods

Throughout the country foods RSA, hunting occurs for:

- moose and mountain sheep in September and October;
- white-tailed deer and mule deer from September to December;
- cougar, bobcat, lynx, black bear, wolf, and coyote variably throughout the year;

- racoon and Columbian ground squirrel throughout the year (no closed season); and
- various game birds and waterfowl typically from September to December (Harper Creek Mining Corp. 2013b).

Fishing and berry/plant harvesting were historically, and continue to be, important activities among people in the area (Chapters 20 and 22).

Objective

The main objective of the country foods baseline assessment was to determine what, if any, risk there is to human consumers of country foods collected from within the country foods baseline LSA and RSA. The country foods baseline methodology and approach followed the AIR (BC EAO 2011) and Health Canada guidance (Health Canada 2010e, 2010d, 2010b). The country foods baseline assessment identified which country foods harvesters were potentially the highest users of the area (and therefore would experience the highest potential risk from country foods consumption) and which country foods were consumed (Appendix 21-A). The concentrations of COPCs in selected country foods were measured or modelled and a risk assessment was completed to determine the potential for human health effects from consumption of selected country food items under baseline conditions.

Data Sources

The country foods assessment relies on a number of data sources which are located in Chapter 13 (Surface Water Quality); Chapter 14 (Fish and Aquatic Resources); Chapter 15 (Terrestrial Ecology); Chapter 16 (Wildlife and Wildlife Habitat); Chapter 17 (Socio-economics); and Chapter 18 (Land and Resource Use). Statistical summaries of the datasets are presented in the Country Foods Baseline Report (Appendix 21-A).

Human receptor consumption characteristics (country food intake amounts, frequencies, and country food species) for the SFN, ALIB, NIB, MNBC, and the LSIB were obtained from the *First Nations Food Nutrition & Environment Study* (Chan et al. 2011) as well as general human characteristics outlined in the literature (Richardson 1997; Health Canada 2010a).

Hunting statistics were obtained from BC MFLNRO for the Thompson #3 Region; however, the data did not indicate if the animals were hunted for consumption, for their fur, or for trophy. Many carnivore species were present in the data set and typically carnivores are not hunted for consumption. Therefore, the BC MFLNRO data was not included as it did not help with the determination of country food species harvested in the area. Instead, the information was obtained from the North Thompson Fish and Game Club as well as the *First Nations Food, Nutrition & Environment Study, Results from BC 2008/2009* by Chan et al. (2011).

Methods

The approach to the country foods baseline study (Appendix 21-A) was based on Health Canada's guidelines for assessing country food issues in environmental impact assessments (Health Canada 2010e, 2010a).

As such, the baseline study was divided into the following six stages.

1. **Problem Formulation:**

   A conceptual model for conducting the country foods risk assessment was developed in the problem formulation stage. This stage identified the country foods selected for evaluation, COPCs, human receptor characteristics, and the exposure routes considered in the assessment.

2. **Exposure Assessment:**

   The measured or modelled COPC concentrations in country foods were integrated with human receptor characteristics to calculate the EDI of COPCs. Food chain modelling of COPC uptake into wildlife tissue is generally highly conservative relative to direct measurement and has the potential to overestimate COPC tissue concentrations by orders of magnitude (Health Canada 2010a). This maintains the conservative nature of the screening-level HHRA and ensures with a high degree of certainty that risks will not be under-estimated or overlooked (Health Canada 2010a).

3. **Toxicity Assessment:**

   The toxicity reference values (TRVs) or 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, namely exposure ratios (ERs) or incremental lifetime cancer risk (ILCR). In addition, the recommended maximum weekly intake (RMWI) for each country food was calculated.

5. **Uncertainty Analysis and Data Gaps:**

   The assumptions made throughout the baseline risk assessment and their effects on the confidence in the conclusions were evaluated.

6. **Conclusions:**

   The potential for risk to human health was assessed based on the results of the risk characterization, with qualitative consideration of uncertainties and data gaps that might influence the quantitative assessment.

Baseline Study Area

The country foods LSA and RSA are shown in Figure 4-1 of Appendix 21-A. The country foods LSA is the same as the wildlife LSA and the boundaries are defined by a buffer that extends 1 km from all sides of proposed Project infrastructure. The country foods LSA is also the same as the LSA used in the human health effects assessment (see Section 21.3.2.2 for more information).

The country foods RSA is defined as the outer boundary formed by the overlay of the wildlife and water quality RSAs and the air quality modelling domain. The country foods RSA is also the same as the RSA used in the human health effects assessment (see Section 21.3.2.2 for more information).

Sampling/Monitoring/Assessment

Environmental quality data (metal chemistry data) were compiled from the baseline monitoring programs for water, soil, and vegetation (Appendix 21-A, Country Foods Baseline Report).

Environmental data collected from within the country foods RSA that were incorporated in the assessment include:

- metal concentrations in stream and lake water samples collected from 20 sites within the country foods LSA and RSA during Project baseline studies between 2007 to 2009 and 2011 to 2014 (Figure 6.3-1 of Appendix 21-A; Harper Creek Mining Corp. 2013a); and
- soil baseline metal concentrations collected in 2012 from 46 sites from within the country foods LSA (Figure 6.2-2 of Appendix 21-A; Harper Creek Mining Corp. 2013c; Sharpe 2013).

Specific metals were selected as COPCs for inclusion in the risk assessment if they met at least one of the following three screening criteria.

1. The maximum metal concentration in soil samples exceeded its CCME soil quality guideline for agricultural land (CCME 2013b).
2. The maximum metal concentration in surface water samples exceeded its BC 30-day mean water criteria or CCME long-term water quality guideline for the protection of aquatic life, whichever was lower (BC MOE 2013h; CCME 2013c).
3. 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 and the United States Environmental Protection Agency (US EPA; JECFA 1972, 1982; US EPA 1997; JECFA 2000; US EPA 2000; JECFA 2005, 2007, 2011).

Metal concentrations in fish (20 Bull Trout, *Salvelinus confluentus*; 30 Rainbow Trout *Oncorhynchus mykiss*) collected from P, T, Baker, Lute, and Jones creeks during baseline sampling in 2011 and 2012 (Knight Piésold Ltd. 2013) were included in the assessment (Figure 6.2-1 of Appendix 21-A). Tissue metal data from eight Rainbow Trout were collected in 2014 from fish from North Barrière Lake. Although this tissue metal from Rainbow Trout from North Barrière Lake was not a part of the country foods baseline assessment as the data became available after the report was written, these data are included in the results of the baseline studies in Section 21.4.3.

No terrestrial wildlife was sacrificed to obtain tissue samples. Instead, tissue metal residues for moose, snowshoe hare, and grouse were predicted using measured surface water, soil, and vegetation metal concentrations from the country foods LSA in a food chain model (Golder Associates Ltd. 2005). For further information on the terrestrial food chain model, refer to Appendix B in Appendix 21-A.

Adults (older than 19 years of age) and toddlers (six months to four years of age) were evaluated for their susceptibility to selected COPCs. Adults comprise the largest section of the population, and include pregnant women and breast-feeding mothers as a sensitive group. Toddlers are considered to be at the most susceptible life stage for chemical exposures because of their higher relative ingestion rates per unit body weight and their rapid absorption and metabolic rates during this important growth period, compared to adults.

21.4.2.3 Drinking Water Quality

<u>Objective</u>

Following the AIR (BC EAO 2011), a comprehensive surface water quality baseline monitoring program was conducted between 2007 and 2014 (Chapter 13, Section 13.4.2, Appendix 13-B). The objective of the water quality baseline program was to collect water quality data from selected stream/river and lake sites near the Project. Water chemistry data from the baseline monitoring program were compiled in Appendices 13-A and 13-B of Chapter 13 (Surface Water Quality Effects Assessment) and these data were then used to assess the potential for human health risk from drinking surface water.

Baseline groundwater quality was monitored as part of the hydrogeology program from 2010 to 2014 (Chapter 11, Section 11.4, Appendix 11-A). Water chemistry data from the baseline monitoring program were then used to assess the potential for human health risks from drinking groundwater under baseline conditions.

<u>Data Sources</u>

Dillon Consulting Limited collected baseline surface water quality samples and *in situ* data since June 2007. In 2011, Knight Piésold Ltd. collected both surface and groundwater quality baseline data for the Project. At that time, the baseline surface water program was re-assessed. New sites were added to the program and lower detection limits were requested from the analytical laboratory to provide a more concise understanding of the concentrations of some of the metals, as the previous detection limits were often greater than the aquatic life guideline limits.

Baseline data for surface water quality are found in Chapter 13 and Appendices 13-A and 13-B. Baseline data for hydrogeology are found in Chapter 11 and Appendix 11-A.

<u>Baseline Study Area</u>

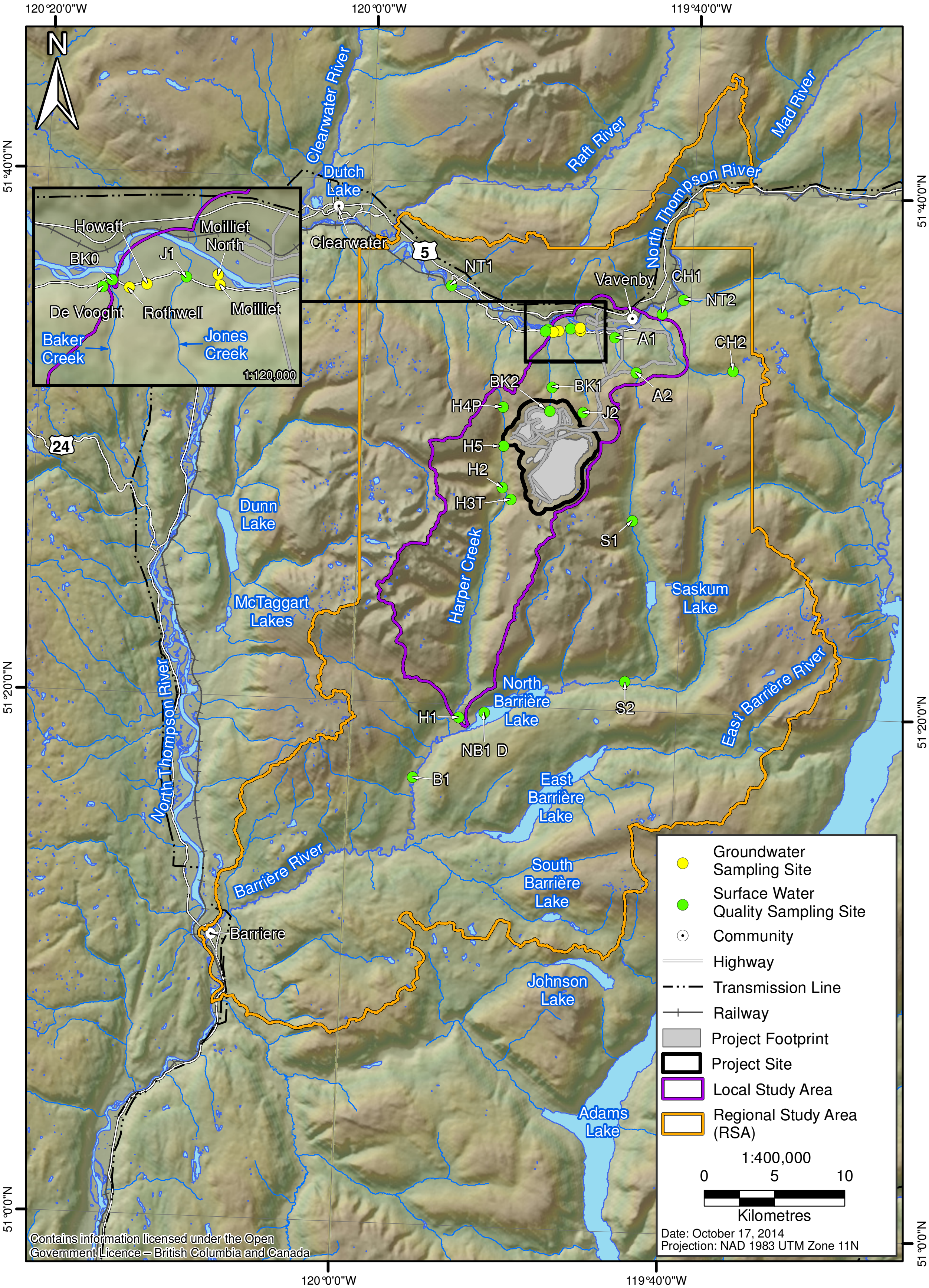
For the surface water quality baseline, seven creeks and rivers were actively sampled as well as North Barrière Lake due to its proximity to the Project. Surface water quality baseline data were available for 23 stream and river sampling sites and a lake sampling site (Figure 21.4-1), which were divided into three main areas: Harper Creek, Barrière, and North Thompson.

Baseline groundwater quality was monitored to assess baseline groundwater quality on August 19, 2013 and on April 28, 2014 at four domestic wells (Howatt, Moilliet, Moilliet North, and Rothwell), which are 4 to 5 km west of Vavenby and were included as human receptor locations (Figure 21.3-1 and Appendix 21-B). The groundwater well sampling also included a surface water sampling location (De Vooght), which was also included as a human receptor location.

Even though 20 boreholes were drilled on the Project Site to assess groundwater quality and flow (see Appendix 11-A), these boreholes were not and are not expected to be used for domestic purposes. There are no domestic water wells on the Project Site. Only the domestic water sources used as drinking water were considered in the assessment of baseline groundwater.

Figure 21.4-1
Drinking Water Baseline Study Area and Water Quality Sampling Locations (2007 - 2014)

ERM



Methods

Surface water sampling methodology is described in Chapter 13 (Section 13.4.1) and Appendix 13-A, and a summary of sampling frequency for the 2007 to 2014 study by month is shown in Table 3.2-1 in the 2014 Water Quality Baseline Report (Appendix 13-A). The water quality samples were analyzed for physical tests (e.g., hardness, pH), total and dissolved metals, nutrients, cyanides, organic carbon, and dissolved anions as described in Appendices 13-A and 13-B.

The methodology for testing groundwater wells for water quality is described in Appendix 11-A, Section 3. Water samples from four domestic wells and one surface water location were submitted for analysis to ALS laboratories in Burnaby, BC.

Sampling/Monitoring/Assessment

Summary statistics (minimum, mean, median, 95th percentile, and maximum) of 764 samples collected from inside the surface water RSA were compared to DWQGs. The quality of surface water in the RSA was compared to BC (BC MOE 2013h) and Canadian DWQGs (Health Canada 2012). In cases where BC DWQGs were absent for a parameter, the Canadian DWQGs were used.

Two groundwater samples were collected from each of the four domestic water supply wells (and one domestic surface water location) in the hydrogeology baseline LSA. The groundwater quality was compared to federal and provincial DWQGs.

The Canadian DWQGs (Health Canada 2012) for colour, total dissolved solids, chloride, sulphate, total aluminum, copper, iron, manganese, sodium, and zinc are based on aesthetic or operational considerations (taste, colour, odour, staining of laundry and plumbing fixtures, and interference with disinfection); therefore, exceedances of these guidelines are unlikely to result in any human toxicological health effects and they were excluded from the assessment. Only health-based drinking water quality guidelines were included in the drinking water assessment.

21.4.2.4 Noise

Objective

The objective of the noise baseline study was to collect information on baseline noise conditions in the vicinity of the proposed Project before Project commencement, and to provide input to the noise assessment modelling (Appendix 10-A of Chapter 10, Noise Effects Assessment).

Data Sources

Full details of the noise baseline are included in the 2012 noise baseline report (Appendix 10-A). No additional data sources were used.

Methods

During the 2012 noise baseline monitoring program, primary locations of anticipated Project-related noise sources were identified, field measurements during snow-free and snow-cover periods were collected, and periods of background noise from recorded data were identified (Appendix 10-A of

Chapter 10, Noise Effects Assessment). The noise baseline study followed methods as described in the AIR (BC EAO 2011).

Three noise monitoring stations (S1, S2, and S3) were set up within the study area and noise levels were recorded over a 24-hour period at each location during the period of September 10 to 17, 2012. The locations were selected to characterize the range of baseline conditions in the region based on their proximity to proposed and local infrastructure and where future mining activities are expected. The instruments were set up to record a range of statistics based on user-specified averaging periods. Full details of the noise monitoring methodology are provided in Chapter 10 and Appendix 10-A.

L_{Aeq} values include higher noise levels from anthropogenic sources such as helicopters and aircraft movement, and therefore may not accurately reflect the natural noise level conditions in the area. L_{A90} values provide a better indication of the natural noise levels in remote locations since discrete events that occur from anthropogenic sources will not typically be part of 90% of the measurement time period. It should be noted, however, that locations S1 and S3 were near enough to anthropogenic sources (trains, traffic, and the sawmill, primarily) that the L_{A90} value would include noise from these sources.

Baseline Study Area

The noise study area was selected to characterize the range of baseline conditions in the region, and the location of the three monitoring stations were based on their proximity to proposed Project and local infrastructure and to where future mining activities are expected (see Figure 3.2-1 in Appendix 10-A).

Sampling/Monitoring/Assessment

Methods employed for the baseline noise sampling program are detailed in Section 10.4 and Appendix 10-A. Three noise monitoring stations were set up within the study area and noise levels were recorded over a 24-hour period in September 2012. Data from the monitoring stations were used to characterize baseline noise levels relative to guidelines and other rural environments.

21.4.3 Existing Conditions

21.4.3.1 Air Quality

Dustfall analyses included particulates (total, soluble, and insoluble) and total metals. The monthly dustfall results ranged from less than 0.10 to 1.53 $mg/dm^2/day$. Maximum dustfall deposition rates of 0.62, 0.82, and 1.53 $mg/dm^2/day$, were measured in 2011, 2012, and 2013, respectively. All the dustfall results measured were below the most conservative BC MOE objective of 1.75 $mg/dm^2/day$ (BC MOE 1979).

Dustfall samples were also analyzed for metals. The majority of metal deposition levels analyzed were either very low or below detection limits. The reported metal deposition rates are predominantly the result of natural sources in the area.

The background PM_{10} concentration was assumed to be 8.8 µg/m³ for a 24-hour averaging time and the background $PM_{2.5}$ concentration was assumed to be 3.2 µg/m³ for 24-hour and annual averaging times, which are the mean background values reported by Cheng et al. (2000) for six rural locations in Alberta. These particulate matter concentrations are well below the federal and provincial air quality criteria (see Table 21.2-2).

A search of the National Pollutant Release Inventory identified one source of air emissions within the RSA, the sawmill in Vavenby (Environment Canada 2014). In 2013, the particulate matter emissions from this source for that year were 30 tonnes of PM_{10} and 4.5 tonnes of $PM_{2.5}$.

21.4.3.2 Country Foods Quality

The selection of country foods for evaluation was based on findings presented in the *First Nations Food Nutrition & Environment Study* (Chan et al. 2011). The country foods identified for evaluation were: moose, snowshoe hare, ruffed grouse, Bull Trout, Rainbow Trout, and huckleberries. For further details on the methodology used for selection of the country foods included in the assessment, refer to Section 6.2 of the Country Foods Baseline Report (Appendix 21-A).

The problem formulation stage of the country foods risk assessment identified several metals as COPCs based on screening (relative to guidelines) of soil and surface water baseline data collected from the country foods LSA. The following 14 COPCs were screened into the assessment: aluminum, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium, and zinc.

Using the measured (Bull Trout, Rainbow Trout, and huckleberries) and modelled (moose, snowshoe hare, and ruffed grouse) concentrations of COPCs in country foods, the EDI of each COPC for toddlers and adult receptors were estimated and are provided in Section 7.5 of Appendix 21-A. It was assumed that 100% of the country foods consumed were harvested from the country foods RSA and that 100% of the COPCs present in the foods were bioavailable (i.e., capable of being absorbed). These assumptions result in a highly conservative estimate of potential risk to human health.

The toxicity reference value (TRV) is defined as the amount of a COPC per unit body weight that can be taken into the body each day (e.g., mg/kg body weight/day) with no risk of adverse health effects. TRVs are safe levels below which there are minimal risks of adverse health effects and were obtained from Health Canada (2010c). Section 8.1 of Appendix 21-A provides the TRV values used in this assessment for both carcinogenic (i.e., arsenic) and non-carcinogenic COPCs.

Using the results of the exposure assessment and the TRV assessment, human health risks from the consumption of country foods were quantified using exposure ratios (ER). The ER is the ratio between the estimated daily intake and the tolerable daily intake and provides a measure of exposure to a COPC through the consumption of country foods. Health effects from chemicals are generally divided into two categories: threshold (i.e., non-carcinogenic) and non-threshold (i.e., carcinogenic) response chemicals. In addition, the RMWI was calculated for each country food evaluated. The RMWIs were compared to current weekly consumption rates of the country foods. The calculations are provided in Appendix 21-A.

The country foods baseline assessment predicted no unacceptable health risks to people from consuming moose, snowshoe hare, ruffed grouse, Rainbow/Bull Trout, and huckleberries 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 process of a country foods risk assessments has inherent uncertainties, which are discussed in detail in the baseline report (Appendix 21-A). A conservative approach was taken in order to overestimate rather than underestimate potential risks.

Rainbow Trout from North Barrière Lake

Additional Rainbow Trout from North Barrière Lake were collected and assessed for tissue metal content after the completion of the country foods baseline report (Appendix 21-A). The assessment of these fish is provided below (Table 21.4-2). Methodology used to assess the risk associated with the consumption of Rainbow Trout from North Barrière Lake is the same as that used in the country foods baseline report (Sections 4.2.2, 4.2.3, and 4.2.4 of Appendix 21-A).

Table 21.4-2 presents the fish tissue metal data, EDIs, and ERs based on the measured metal concentrations in Rainbow Trout from North Barrière Lake. The BC MOE (Beatty and Russo 2014) recently updated selenium screening values for three levels of fish consumption to protect human health. For a high fish consumption rate (over 220 grams [g]/day), the recommended selenium concentration in fish tissue is below 1.8 mg/kg wet weight (ww), which is the most conservative guideline for human fish consumption. All Rainbow Trout tissue selenium concentrations measured from North Barrière Lake (Chapter 14, Appendix 14-B) were lower than the screening value for high fish consumption of 1.8 mg/kg ww.

Calculated ERs for Rainbow Trout from North Barrière Lake were all below 0.2, except for methylmercury for toddlers (ER = 0.327; Table 21.4-2). ER values greater than 0.2 do not necessarily indicate that adverse health effects will occur since TRVs are conservative and protect human health based on the application of uncertainty factors. ERs are not a measure of actual risk, but are rather measures of level of concern (Tannenbaum, Johnson, and Bazar 2003).

Methylmercury bioaccumulates within the food chain and tends to accumulate in higher trophic level consumers, including humans. Rainbow Trout are higher trophic level organisms within the freshwater food chain and therefore are likely to accumulate mercury to a greater extent than other lower trophic level organisms. The Rainbow Trout collected in 2014 were from North Barrière Lake, and they likely spent a higher amount of time in this lentic environment resulting in higher mercury concentrations in comparison to Rainbow Trout collected from Baker, Lute, and Jones creeks.

RMWIs were calculated as described by Health Canada (Health Canada 2010b). For calculation of RMWI, the yearly averaged ingestion rate from Chan et al. (2011) was not used, as averaged yearly serving sizes are very small resulting in an overestimation of the actual RMWI. Thus, more realistic daily serving sizes provided by Richardson (1997) were used in the calculation instead (Table 21.4-3).

Table 21.4-2. Exposure Assessment for Rainbow Trout Collected in 2014 from North Barrière Lake

COPC	95% UCLM Metal Concentration in Rainbow Trout Muscle Tissue (mg/kg ww)	Body Weight (kg)		Ingestion Rate (kg/day)		EDI (mg COPC/kg/day)		TRV (mg/kg BW/day)		Exposure Ratio (unitless)		ELDE (mg/kg/day)	ILCR (unitless)
		Adult	Toddler	Adult	Toddler	Adult	Toddler	Adult	Toddler	Adult	Toddler		
Aluminum	0.500	70.7	16.5	0.0114	0.00490	8.06×10^{-5}	1.49×10^{-4}	1 [a]	1 [a]	8.06×10^{-5}	1.49×10^{-4}	-	-
Arsenic *	0.00643	70.7	16.5	0.0114	0.00490	1.04×10^{-6}	1.91×10^{-6}	0.0003 [b]	0.0003 [b]	3.46×10^{-3}	6.37×10^{-3}	1.04×10^{-6}	1.87×10^{-6}
Cadmium	0.00100	70.7	16.5	0.0114	0.00490	1.61×10^{-7}	2.97×10^{-7}	0.001 [c]	0.001 [c]	1.61×10^{-4}	2.97×10^{-4}	-	-
Chromium	0.125	70.7	16.5	0.0114	0.00490	2.01×10^{-5}	3.70×10^{-5}	0.001 [c]	0.001 [c]	2.01×10^{-2}	3.70×10^{-2}	-	-
Cobalt	0.00200	70.7	16.5	0.0114	0.00490	3.22×10^{-7}	5.94×10^{-7}	0.01 [d]	0.01 [d]	3.22×10^{-5}	5.94×10^{-5}	-	-
Copper	0.256	70.7	16.5	0.0114	0.00490	4.12×10^{-5}	7.60×10^{-5}	0.141 [c]	0.091 [c]	2.92×10^{-4}	8.35×10^{-4}	-	-
Lead	0.0156	70.7	16.5	0.0114	0.00490	2.52×10^{-6}	4.64×10^{-6}	0.00357 [e]	0.00357 [e]	7.06×10^{-4}	1.30×10^{-3}	-	-
Methyl-Mercury **	0.253	70.7	16.5	0.0114	0.00490	4.08×10^{-5}	7.52×10^{-5}	0.00047 [e]	0.00023 [e]	8.68×10^{-2} [f]; 1.77×10^{-1} [g]	3.27×10^{-1}	-	-
Nickel	0.0200	70.7	16.5	0.0114	0.00490	3.22×10^{-6}	5.94×10^{-6}	0.025 [e]	0.025 [e]	1.29×10^{-4}	2.38×10^{-4}	-	-
Selenium	0.274	70.7	16.5	0.0114	0.00490	4.41×10^{-5}	8.13×10^{-5}	0.0057 [c]	0.0062 [c]	7.74×10^{-3}	1.31×10^{-2}	-	-
Thallium	0.00911	70.7	16.5	0.0114	0.00490	1.47×10^{-6}	2.71×10^{-6}	0.00007 [e]	0.00007 [e]	2.10×10^{-2}	3.87×10^{-2}	-	-
Vanadium	0.0100	70.7	16.5	0.0114	0.00490	1.61×10^{-6}	2.97×10^{-6}	0.009 [b]	0.009 [b]	1.79×10^{-4}	3.30×10^{-4}	-	-
Zinc	3.47	70.7	16.5	0.0114	0.00490	5.59×10^{-4}	1.03×10^{-3}	0.57 [c]	0.48 [c]	9.81×10^{-4}	2.15×10^{-3}	-	-

Notes:

COPC = contaminant of potential concern; TRV = toxicity reference value; BW = body weight; ww = wet weight; EDI = estimated daily intake; ER = exposure ratio; ELDE = estimated lifetime daily exposure

ILCR = incremental lifetime cancer risk. An ILCR estimate less than 1×10^{-5} is normally considered acceptable (Health Canada 2010b). ILCR is calculated using an oral slope factor for arsenic of 1.8 $(mg/kg/day)^{-1}$.

[a] *ATDSR (2008)*

[b] *US EPA (2013)*

[c] *Health Canada (2010c)*

[d] *ATSDR (2004)*

[e] *Health Canada (2011)*

[f] *Exposure ratio for adults.*

[g] *Exposure ratio for women of child-bearing age and pregnant women.*

** Inorganic arsenic concentrations in fish tissues were estimated based on proportions of inorganic arsenic to total arsenic concentrations (i.e., 0.1) in Schoof et al. (1999). See Section 8.2.2 of the country foods baseline report for further explanation.*

*** Methylmercury TRV for general public eating fish is 0.00047 mg/kg BW/day, while that for children, women of child-bearing age, and pregnant women eating fish is 0.00023 mg/kg BW/day. Methylmercury concentrations were not measured; however, mercury in fish is assumed to be present 100% as methylmercury (Health Canada 2007). Therefore, for fish, ERs were calculated for toddlers, adults, and women of child-bearing age.*

Grey shading indicates an exposure ratio greater than 0.2 (Health Canada 2010b).

Table 21.4-3. Recommended Weekly Intake and Recommended Number of Servings of Rainbow Trout Collected in 2014 from North Barrière Lake

COPC	RMWI (kg/week)			Serving Size (kg/day) [a]		Recommended Number of Servings per Week		
	Adult	Sensitive Adult [b]	Toddler	Adult	Toddler	Adult	Sensitive Adult [b]	Toddler
Methyl-mercury	0.919	0.450	0.105	0.220	0.0950	4.18	2.04	1.10

Notes:
RMWI = recommended maximum weekly intake
[a] Based on serving sizes from Richardson (1997).
[b] Sensitive adults are women of child-bearing age and pregnant women.

The lowest RMWI for each receptor group was selected as the overall RMWI for Rainbow Trout collected from North Barrière Lake in 2014. The lowest RMWI for adults, sensitive adults (women of child-bearing age and pregnant women) and toddlers consuming Rainbow Trout was due to methylmercury. Table 21.4-3 provides the lowest RMWIs for receptor groups consuming Rainbow Trout from North Barrière Lake. Based on the calculated RMWIs for toddlers, adults (general public), and sensitive adults (women of child-bearing age and pregnant women), it is recommended to limit regular weekly consumption of Rainbow Trout from North Barrière Lake to four servings for adults, two servings for sensitive adults, and a single serving for toddlers.

The recommendation to limit fish consumption was based on the assumption that adults consume 220 g/day and toddlers 95 g/day of Rainbow Trout from North Barrière Lake daily. Although the portion sizes are reasonable, daily consumption of Rainbow Trout exclusively from North Barrière Lake is unlikely. Mercury content of all eight Rainbow Trout collected from North Barrière Lake in 2014 was below the Health Canada guideline of 0.5 mg/kg (Health Canada 2007). In addition, the baseline Rainbow Trout metal data from North Barrière Lake rely on limited fish tissue metal data (n = 8) collected during June 2014. Therefore, the above recommendations regarding limiting Rainbow Trout consumption is based on limited data and conservative assumptions; additional data may be required before a consumption advisory would be considered (Appendix 21-A).

It is important to re-iterate that the elevated mercury measured during baseline studies in Rainbow Trout tissue in North Barrière Lake is a naturally occurring condition and is not associated with the development of the proposed Project (since the Project does not yet exist).

21.4.3.3 Drinking Water Quality

Table 21.4-4 provides the statistical summary of baseline concentration of metals in surface waters between 2007 and 2014 for the parameters with DWQGs from sites sampled during the baseline monitoring program in the Harper Creek, Barrière, and North Thompson areas. The baseline assessment relies on health-based DWQGs and assumes that people may drink surface water from streams anywhere inside the RSA, which may be treated or not treated for chemical contaminants (i.e., metals), dependent on the preferred practice of the land user.

Table 21.4-4. Comparison of Baseline Surface Water Quality to Canadian and British Columbian Drinking Water Guidelines in the Regional Study Area, 2007 to 2014

		Drinking Water Quality Guidelines		Barrière Sites (Sites S1, S2, NB1, and B1)							
Parameter	Detection Limits	BC	Canadian	N	Minimum	Mean	Median	95th Percentile	Maximum	Standard Deviation	Standard Error
Fluoride	0.01 - 0.05	1	1.5	116	0.0200	0.0428	0.0415	0.0606	0.0700	0.0115	0.00107
Nitrate	0.005 - 0.05	10	10	116	0.00250	0.0811	0.0700	0.215	0.290	0.0651	0.00604
Nitrite	0.001 - 0.005	1	-	116	0.000500	0.00148	0.00100	0.00250	0.00330	0.000995	0.0000924
Sulphate	0.5	500	-	114	0.250	2.15	1.82	4.03	11.4	1.36	0.127
Thiocyanate and Cyanide	0.0004 - 0.0005	0.2	0.2	53	0.000200	0.000432	0.000250	0.00114	0.00160	0.000347	0.0000476
Antimony, total	0.00002 - 0.001	0.014	0.006	122	0.0000100	0.000144	0.000100	0.000250	0.000375	0.000108	0.00000975
Arsenic, total	0.00002 - 0.0005	0.025	0.01	122	0.0000500	0.000237	0.000160	0.000442	0.00295	0.000374	0.0000339
Barium, total	0.00002 - 0.02	-	1	122	0.00400	0.00710	0.00650	0.0100	0.0115	0.00179	0.000162
Beryllium, total	0.00001 - 0.001	0.004	-	122	0.00000500	0.000131	0.0000500	0.000500	0.000500	0.000184	0.0000167
Boron, total	0.01 - 0.3	5	5	122	0.00500	0.0230	0.0250	0.0500	0.0500	0.0162	0.00147
Cadmium, total	0.000005 - 0.00005	-	0.005	122	0.00000250	0.0000133	0.00000500	0.0000495	0.000200	0.0000231	0.00000209
Chromium, total	0.0001 - 0.002	-	0.05	122	0.0000500	0.000358	0.000500	0.000510	0.00270	0.000303	0.0000274
Copper, total	0.00005 - 0.004	0.5	1	122	0.000110	0.000848	0.000500	0.00160	0.0217	0.00197	0.000178
Lead, total	0.000005 - 0.0005	0.05	0.01	122	0.00000250	0.000244	0.000100	0.000752	0.00880	0.000817	0.0000740
Mercury, total	0.000002 - 0.0002	0.001	0.001	120	0.00000100	0.0000104	0.0000100	0.0000250	0.000231	0.0000209	0.00000191
Molybdenum, total	0.00001 - 0.002	0.25	-	122	0.000500	0.00149	0.00120	0.00328	0.00408	0.000838	0.0000759
Selenium, total	0.00001 - 0.001	0.01	0.01	122	0.0000200	0.000138	0.0000500	0.000500	0.000500	0.000181	0.0000164
Thallium, total	0.000002 - 0.0002	0.002	-	122	0.00000100	0.0000293	0.0000100	0.000100	0.000100	0.0000364	0.00000329
Uranium, total	0.000002 - 0.0002	-	0.02	122	0.000795	0.00189	0.00151	0.00358	0.00460	0.000867	0.0000785
Zinc, total	0.0001 - 0.01	5	5	122	0.000100	0.00248	0.00250	0.00695	0.0148	0.00238	0.000216
Aluminum, dissolved	0.0002 - 0.005	0.2	-	122	0.00390	0.0273	0.0281	0.0610	0.0900	0.0174	0.00157

(continued)

Table 21.4-4. Comparison of Baseline Surface Water Quality to Canadian and British Columbian Drinking Water Guidelines in the Regional Study Area, 2007 to 2014 (continued)

		Drinking Water Quality Guidelines		Harper Creek Sites (Sites H4P, H5, H2, H3T, and H1)							
Parameter	Detection Limits	BC	Canadian	N	Minimum	Mean	Median	95th Percentile	Maximum	Standard Deviation	Standard Error
Fluoride	0.01 - 0.05	1	1.5	232	0.00500	0.0288	0.0290	0.0480	0.0570	0.0112	0.000736
Nitrate	0.005 - 0.05	10	10	232	0.00250	0.112	0.0965	0.337	0.755	0.111	0.00729
Nitrite	0.001 - 0.005	1	-	232	0.000500	0.00110	0.000500	0.00250	0.00450	0.000925	0.0000608
Sulphate	0.5	500	-	228	0.250	5.67	4.49	13.7	15.9	4.14	0.274
Thiocyanate and Cyanide	0.0004 - 0.0005	0.2	0.2	66	0.000200	0.000354	0.000250	0.00120	0.00130	0.000287	0.0000353
Antimony, total	0.00002 - 0.001	0.014	0.006	246	0.0000100	0.000103	0.0000500	0.000250	0.000250	0.0000927	0.00000591
Arsenic, total	0.00002 - 0.0005	0.025	0.01	246	0.0000500	0.000372	0.000240	0.000900	0.00816	0.000652	0.0000416
Barium, total	0.00002 - 0.02	-	1	246	0.00352	0.00725	0.00673	0.0107	0.0118	0.00209	0.000133
Beryllium, total	0.00001 - 0.001	0.004	-	246	0.00000500	0.000100	0.0000500	0.000500	0.000500	0.000150	0.00000960
Boron, total	0.01 - 0.3	5	5	246	0.00500	0.0162	0.00500	0.0500	0.0500	0.0154	0.000979
Cadmium, total	0.000005 - 0.00005	-	0.005	246	0.00000250	0.0000144	0.00000650	0.0000465	0.000172	0.0000183	0.00000117
Chromium, total	0.0001 - 0.002	-	0.05	246	0.0000500	0.000218	0.000120	0.000500	0.000750	0.000194	0.0000124
Copper, total	0.00005 - 0.004	0.5	1	246	0.000250	0.00189	0.000800	0.00870	0.0165	0.00278	0.000177
Lead, total	0.000005 - 0.0005	0.05	0.01	246	0.00000250	0.000142	0.000100	0.000392	0.00278	0.000256	0.0000163
Mercury, total	0.000002 - 0.0002	0.001	0.001	241	0.00000100	0.0000138	0.00000500	0.0000100	0.00130	0.0000854	0.00000550
Molybdenum, total	0.00001 - 0.002	0.25	-	244	0.0000760	0.000863	0.000626	0.00224	0.00260	0.000705	0.0000451
Selenium, total	0.00001 - 0.001	0.01	0.01	246	0.0000200	0.000138	0.000100	0.000500	0.000500	0.000144	0.00000920
Thallium, total	0.000002 - 0.0002	0.002	-	246	0.00000100	0.0000194	0.00000500	0.000100	0.000100	0.0000310	0.00000198
Uranium, total	0.000002 - 0.0002	-	0.02	246	0.0000200	0.000479	0.000260	0.00160	0.00220	0.000506	0.0000323
Zinc, total	0.0001 - 0.01	5	5	246	0.000100	0.00223	0.00150	0.00580	0.0220	0.00196	0.000125
Aluminum, dissolved	0.0002 - 0.005	0.2	-	245	0.00180	0.0266	0.0185	0.0770	0.0976	0.0226	0.00144

(continued)

Table 21.4-4. Comparison of Baseline Surface Water Quality to Canadian and British Columbian Drinking Water Guidelines in the Regional Study Area, 2007 to 2014 (completed)

		Drinking Water Quality Guidelines		North Thompson Sites (Sites NT2, A2, A1, CH2, CH1, J2, J1, BK2, BK1, BK0, and NT1)							
Parameter	Detection Limits	BC	Canadian	N	Minimum	Mean	Median	95th Percentile	Maximum	Standard Deviation	Standard Error
Fluoride	0.01 - 0.05	1	1.5	379	0.0100	0.0351	0.0300	0.0761	0.116	0.0196	0.00101
Nitrate	0.005 - 0.05	10	10	379	0.00250	0.0507	0.0201	0.186	0.291	0.0647	0.00332
Nitrite	0.001 - 0.005	1	-	379	0.000500	0.00129	0.000500	0.00250	0.00700	0.00104	0.0000533
Sulphate	0.5	500	-	374	0.250	7.60	6.06	20.0	27.9	5.53	0.286
Thiocyanate and Cyanide	0.0004 - 0.0005	0.2	0.2	142	0.000250	0.000435	0.000250	0.00120	0.00150	0.000338	0.0000283
Antimony, total	0.00002 - 0.001	0.014	0.006	397	0.0000100	0.000124	0.0000500	0.000250	0.000250	0.000100	0.00000504
Arsenic, total	0.00002 - 0.0005	0.025	0.01	397	0.0000100	0.000392	0.000200	0.00110	0.0107	0.00105	0.0000527
Barium, total	0.00002 - 0.02	-	1	397	0.000250	0.0126	0.0100	0.0261	0.0383	0.00669	0.000336
Beryllium, total	0.00001 - 0.001	0.004	-	397	0.00000500	0.000107	0.0000500	0.000500	0.000500	0.000159	0.00000797
Boron, total	0.01 - 0.3	5	5	397	0.00500	0.0190	0.0250	0.0500	0.150	0.0169	0.000850
Cadmium, total	0.000005 - 0.00005	-	0.005	397	0.00000250	0.00000832	0.00000500	0.0000242	0.0000760	0.00000946	0.000000475
Chromium, total	0.0001 - 0.002	-	0.05	397	0.00000400	0.000589	0.000500	0.00215	0.00556	0.000827	0.0000415
Copper, total	0.00005 - 0.004	0.5	1	397	0.0000900	0.00167	0.000680	0.00344	0.229	0.0115	0.000577
Lead, total	0.000005 - 0.0005	0.05	0.01	397	0.00000250	0.000276	0.000100	0.00100	0.00669	0.000584	0.0000293
Mercury, total	0.000002 - 0.0002	0.001	0.001	392	0.00000100	0.00000844	0.00000500	0.0000239	0.000200	0.0000110	0.000000556
Molybdenum, total	0.00001 - 0.002	0.25	-	395	0.0000250	0.000337	0.000330	0.000500	0.00146	0.000180	0.00000908
Selenium, total	0.00001 - 0.001	0.01	0.01	397	0.0000200	0.000161	0.0000660	0.000500	0.000700	0.000161	0.00000810
Thallium, total	0.000002 - 0.0002	0.002	-	397	0.00000100	0.0000246	0.0000100	0.000100	0.000100	0.0000320	0.00000161
Uranium, total	0.000002 - 0.0002	-	0.02	397	0.00000500	0.000330	0.000230	0.00100	0.00142	0.000310	0.0000155
Zinc, total	0.0001 - 0.01	5	5	396	0.0000500	0.00284	0.00250	0.00618	0.181	0.00921	0.000463
Aluminum, dissolved	0.0002 - 0.005	0.2	-	396	0.000500	0.0200	0.0111	0.0671	0.0990	0.0217	0.00109

Notes:
All concentrations in mg/L.
NA = not available
Grey shading indicates an exceedance of drinking water quality guidelines.

Mercury was the only parameter that was found to be greater than the BC DWQG (Table 21.4-4). Total mercury was measured to be 0.0013 mg/L in a single sample collected from the H1 site in lower Harper Creek, which is greater than the BC DWQG for mercury (0.001 mg/L; BC MOE 2013h); the concentration of total mercury in the sample was below the Health Canada DWQG for mercury (0.05 mg/L; Health Canada 2012). There were 50 samples from site H1 analyzed for mercury, thus only 2% of the samples exceeded the BC DWQG.

Drinking water consumption amounts and frequency of consumption by transient potential users (such as hunters, trappers, or hikers) are not known, and it is possible that users may bring water with them from other sources outside of the LSA, particularly on day trips. There is one surface water licence (C041839) close to the H1 site, thus there are known permanent drinking water users near the site.

Elevated mercury in surface water at the H1 site does not appear to be a normal occurrence (i.e., the single sample with elevated mercury is anomalous), since all other samples collected at this site had mercury concentrations that were below detection limits (Appendix 13-A and 13-B). In November 2013, the BC MOE made a recommendation that water samples be field-filtered, preserved, and placed in special bottles for mercury analysis due to potential losses and contamination (ALS Environmental 2013). These procedures were not in place when the H1 sample was collected in 2009, further indicating that the mercury concentration may not be reliable.

Total metals concentrations, physical tests, dissolved anions, nutrients, and organics sampled at the four domestic groundwater wells and the one domestic surface water location were compared to health-based federal and provincial DWQGs (Section 11.4.1.5 and Appendix 11-A). None of the domestic wells or the surface water location had concentrations of parameters above the health-based federal and provincial DWQGs.

21.4.3.4 Noise

For context, examples of typical noise levels (not related to the Project) include (in dBA):

- rustling leaves: 20;
- refrigerator humming: 40;
- normal conversation: 60;
- business office: 65;
- average city traffic: 80 to 85;
- jackhammer: 100;
- jet take-off at 100 m distance: 130; and
- motorcycles, firecrackers, small arms fire: up to 140.

Natural background noise sources observed included birds, small mammals, wind, and rain. Anthropogenic noise sources observed included aircraft (helicopters and fixed wing), road vehicles, trains, and general human activity. Recorded noise levels were lowest at station S2 and the highest noise levels were recorded at station S3. From the background data collected at the monitoring station during the monitoring period:

- the daily logarithmic average noise (L_{Aeq}) levels that were measured ranged from 32 (S2) to 56 (S3) dBA;

- the daily average noise (L_{A90}) levels that were measured ranged from 21 (S2) to 42 (S3) dBA;
- the daily minimum (L_{Amin}) noise levels ranged from 20 (S2) to 40 (S3) dBA; and
- the daily maximum (L_{Amax}) noise levels ranged from 48 (S2) to 73 (S1) dBA.

The L_{Aeq} values are in the range that would be expected for baseline rural noise levels: approximately 35 dBA during the nighttime and around 45 dBA during the daytime. Higher values, such as at station S3, are due to anthropogenic activity (mostly helicopters) in the study area.

Given that the Project is located within a relatively undeveloped area, baseline noise levels are considered to be low. Noise levels monitored within the study area are comparable to baseline levels for rural areas suggested in the Alberta Energy and Utilities Board Directive (Alberta ERCB 2007).

21.5 Effects Assessment and Mitigation

Figure 21.5-1 is a simplified diagram of the pathways by which human receptors may potentially be exposed to Project-related emissions containing contaminants that may be released to the atmospheric, aquatic, and terrestrial environments. The conceptual model guides the remainder of the human health effects assessment where COPCs are selected, screened for potential to cause adverse effects in human receptors, and the risk to human health is determined.

The potential effects to be assessed for human health are those that result from Project-related changes to air quality, drinking water quality, quality of country foods, and noise. The selection of Project phases for assessment was made based on characterization of a particular phase as the "worst-case" phase to provide the most conservative assessment.

The following sections describe in further detail the key potential effects that human receptors may experience as a result of Project-related noise, changes in air quality, drinking water quality, and country foods quality. Key potential effects were identified in Table 21.5-1 as activities or components that have moderate (yellow highlighted) or high (red highlighted) potential to affect human health. Mitigation measures to avoid, control, and mitigate these potential human health effects are described in Section 21.5.2.

21.5.1 Screening Project Effects

21.5.1.1 Air Quality

Air quality contributes directly and indirectly to human health. Direct effects include the inhalation of CACs and metals in dust from the air. CACs and metals can have a direct health effect on people, especially sensitive members of the population (children, elderly, and people with pre-existing conditions such as asthmatics). Indirect effects can include the deposition and uptake of dust-associated metals by soils and plants and subsequently by animals within the food chain. These animals and plants may be used as country foods, thereby providing a pathway for dust-associated metals to contribute to the overall metal and trace mineral concentration in human tissues.

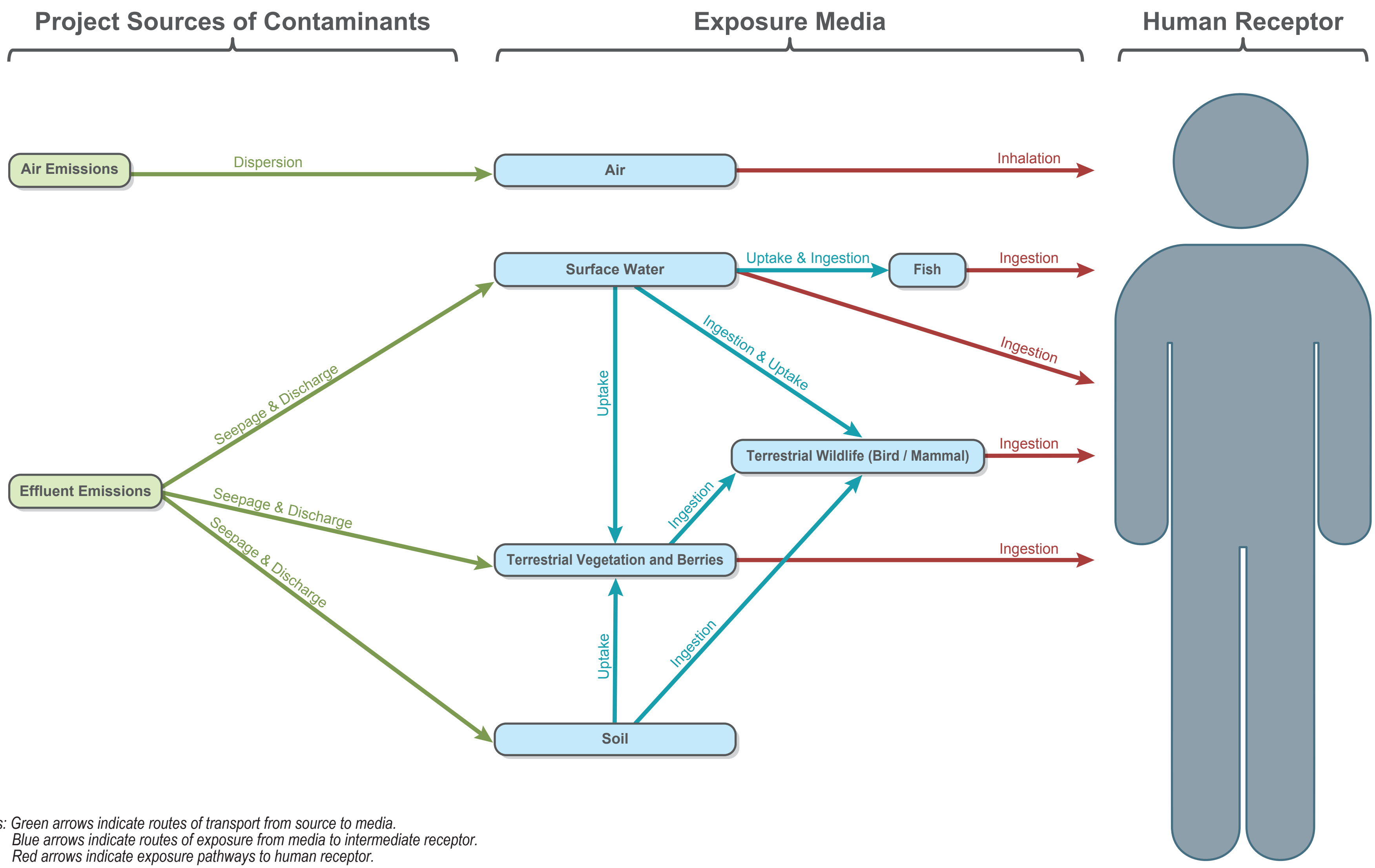
Table 21.5-1. Risk Ratings of Project Effects on Human Health Valued Components

Category	Project Components and Activities	Air quality	Country Foods Quality	Drinking Water Quality	Noise
Construction					
Concrete production	Concrete batch plant installation, operation and decommissioning	● (green)	● (green)		● (green)
Dangerous goods and hazardous materials	Hazardous materials storage, transport, and off-site disposal	● (yellow)	● (yellow)		● (yellow)
	Spills and emergency management				
Environmental management and monitoring	Construction of fish habitat offsetting sites	● (green)	● (green)	● (green)	● (green)
Equipment	On-site equipment and vehicle use: heavy machinery and trucks	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Explosives	Explosives storage and use	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Fuel supply, storage and distribution	Fuel supply, storage and distribution	● (yellow)	● (yellow)		● (yellow)
Open pit	Open pit development - drilling, blasting, hauling and dumping	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Potable water supply	Process and potable water supply, distribution and storage				
Power supply	Auxiliary electricity - diesel generators	● (yellow)	● (yellow)		● (green)
	Power line and site distribution line construction: vegetation clearing, access, poles, conductors, tie-in	● (green)	● (yellow)	● (yellow)	● (green)
Processing	Plant construction: mill building, mill feed conveyor, truck shop, warehouse, substation and pipelines	● (yellow)	● (yellow)	● (green)	● (yellow)
	Primary crusher and overland feed conveyor installation	● (green)	● (green)		● (green)
Procurement and labour	Employment and labour				
	Procurement of goods and services				
Project Site development	Aggregate sources/ borrow sites: drilling, blasting, extraction, hauling, crushing	● (yellow)	● (yellow)	● (yellow)	● (yellow)
	Clearing vegetation, stripping and stockpiling topsoil and overburden, soil salvage handling and storage	● (yellow)	● (yellow)	● (yellow)	● (yellow)
	Earth moving: excavation, drilling, grading, trenching, backfilling	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Rail load-out facility	Rail load-out facility upgrade and site preparation	● (green)	● (green)	● (green)	● (green)
Roads	New TMF access road construction: widening, clearing, earth moving, culvert installation using non-PAG material	● (green)	● (yellow)	● (yellow)	● (green)
	Road upgrades, maintenance and use: haul and access roads	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Stockpiles	Coarse ore stockpile construction	● (yellow)	● (yellow)	● (yellow)	● (yellow)
	Non-PAG Waste Rock Stockpile construction	● (yellow)	● (yellow)	● (yellow)	● (yellow)
	PAG and Non-PAG Low-grade ore stockpiles foundation construction	● (yellow)	● (yellow)	● (yellow)	● (yellow)
	PAG Waste Rock stockpiles foundation construction	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Tailings management	Coffer dam and South TMF embankment construction	● (yellow)	● (yellow)	● (yellow)	● (green)
	Tailings distribution system construction	● (green)	● (green)	● (green)	● (green)
Temporary construction camp	Construction camp construction, operation, and decommissioning	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Traffic	Traffic delivering equipment, materials and personnel to site	● (yellow)	● (yellow)	● (green)	● (yellow)
Waste disposal	Waste management: garbage, incinerator and sewage waste facilities	● (yellow)	● (yellow)	● (green)	● (green)
Water management	Ditches, sumps, pipelines, pump systems, reclaim system and snow clearing/stockpiling	● (green)	● (green)		● (green)
	Water management pond, sediment pond, diversion channels and collection channels construction	● (green)	● (yellow)	● (yellow)	● (green)
Operations 1					
Concentrate transport	Concentrate transport by road from mine to rail loadout	● (yellow)	● (yellow)		● (yellow)
Dangerous goods and hazardous materials	Explosives storage and use	● (yellow)	● (yellow)	● (yellow)	● (yellow)
	Hazardous materials storage, transport, and off-site disposal	● (yellow)	● (yellow)		● (yellow)
	Spills and emergency management				
Environmental management and monitoring	Fish habitat offsetting site monitoring and maintenance		● (green)	● (green)	
Equipment fleet	Mine site mobile equipment (excluding mining fleet) and vehicle use	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Fuel supply, storage and distribution	Fuel storage and distribution	● (green)	● (green)		● (green)
Mining	Mine pit operations: blast, shovel and haul	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Ore processing	Ore crushing, milling, conveyance and processing	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Potable water supply	Process and potable water supply, distribution and storage				
Power supply	Backup diesel generators				
	Electrical power distribution				
Processing	Plant operation: mill building, truck shop, warehouse and pipelines	● (yellow)	● (yellow)		● (yellow)
Procurement and labour	Employment and labour				
	Procurement of goods and services				
Rail load-out facility	Rail-load out activity (loading of concentrate; movement of rail cars on siding)	● (green)	● (green)		● (green)
Reclamation and decommissioning	Progressive mine reclamation	● (green)	● (yellow)	● (yellow)	● (green)
Stockpiles	Construction of Non-PAG tailings beaches	● (yellow)	● (yellow)	● (green)	● (green)
	Construction of PAG and Non-PAG Low Grade Ore Stockpile	● (yellow)	● (red)	● (red)	● (green)
	Non-PAG Waste Rock Stockpiling	● (yellow)	● (red)	● (red)	● (green)
	Overburden stockpiling	● (yellow)	● (yellow)	● (yellow)	● (green)
Tailings management	Reclaim barge and pumping from TMF to Plant Site		● (green)	● (green)	
	South TMF embankment construction	● (green)	● (yellow)	● (yellow)	● (green)
	Sub-aqueous deposition of PAG waste rock into TMF		● (green)	● (green)	
	Tailings transport and storage in TMF		● (green)	● (green)	
	Treatment and recycling of supernatant TMF water		● (green)	● (green)	
Traffic	Traffic delivering equipment, materials and personnel to site	● (yellow)	● (yellow)		● (yellow)
Waste disposal	Waste management: garbage and sewage waste facilities	● (green)	● (green)	● (green)	● (green)
Water management	Monitoring and maintenance of mine drainage and seepage		● (green)	● (green)	
	Surface water management and diversions systems including snow stockpiling/clearing				
Operations 2	***Includes the Operations 1 non-mining Project Components and Activities, with the addition of these activities:***				
Processing	Low grade ore crushing, milling and processing	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Reclamation and decommissioning	Partial reclamation of Non-PAG waste rock stockpile	● (green)	● (yellow)	● (yellow)	● (green)
	Partial reclamation of TMF tailings beaches and embankments	● (green)	● (yellow)	● (yellow)	● (green)
Tailings management	Construction of North TMF embankment and beach	● (green)	● (yellow)	● (yellow)	● (green)
	Deposit of low grade ore tailings into open pit	● (green)	● (green)	● (green)	● (green)
Water management	Surface water management				
Closure					
Environmental management and monitoring	Environmental monitoring including surface and groundwater monitoring				
	Monitoring and maintenance of mine drainage, seepage, and discharge		● (green)	● (green)	
	Reclamation monitoring and maintenance		● (green)	● (green)	
Open pit	Filling of open pit with water and storage of water as a pit lake		● (yellow)	● (yellow)	
Procurement and labour	Employment and labour				
	Procurement of goods and services				
Reclamation and decommissioning	Decommissioning of rail concentrate loadout area	● (green)	● (green)	● (green)	
	Partial decommissioning and reclamation of mine site roads	● (green)	● (green)	● (green)	● (green)
	Decommissioning and removal of plant site, processing plant and mill, substation, conveyor, primary crusher, and	● (green)	● (green)	● (green)	● (green)
	Decommissioning of diversion channels and distribution pipelines	● (green)	● (green)	● (green)	● (green)
	Decommissioning of reclaim barge				
	Reclamation of Non-PAG LGO stockpile, overburden stockpile and Non-PAG waste rock stockpile	● (green)	● (yellow)	● (yellow)	● (green)
	Reclamation of TMF embankments and beaches	● (green)	● (yellow)	● (yellow)	● (green)
	Removal of contaminated soil	● (green)	● (green)	● (green)	● (green)
	Use of topsoil for reclamation	● (green)	● (yellow)	● (yellow)	● (green)
Stockpiles	Storage of waste rock in the non-PAG waste rock stockpile		● (yellow)	● (yellow)	● (green)
Tailings management	Construction and activation of TMF closure spillway		● (yellow)	● (yellow)	● (green)
	Maintenance and monitoring of TMF		● (green)	● (green)	
	Storage of water in the TMF and groundwater seepage		● (yellow)	● (yellow)	
	Sub-aqueous tailing and waste rock storage in TMF		● (green)	● (green)	
	TMF discharge to T-Creek		● (red)	● (red)	
Waste disposal	Solid waste management	● (green)	● (green)		● (green)
Post-Closure					
Environmental management and monitoring	Environmental monitoring including surface and groundwater monitoring		● (green)	● (green)	
	Monitoring and maintenance of mine drainage, seepage, and discharge		● (green)	● (green)	
	Reclamation monitoring and maintenance		● (green)	● (green)	
Open pit	Construction of emergency spillway on open pit		● (green)	● (green)	
	Storage of water as a pit lake		● (yellow)	● (yellow)	
Procurement and labour	Procurement of goods and services				
Stockpiles	Storage of waste rock in the non-PAG waste rock stockpile		● (yellow)	● (yellow)	
Tailings management	Storage of water in the TMF and groundwater seepage		● (yellow)	● (yellow)	
	Sub-aqueous tailing and waste rock storage		● (green)	● (green)	
	TMF discharge		● (red)	● (red)	

Notes:
** Includes Operations 1 and Operations 2 as described in the temporal boundaries.*
● (green) = *Low risk interaction: a negligible to minor adverse effect could occur; no further consideration warranted.*
● (yellow) = *Moderate risk interaction: a potential moderate adverse effect could occur; warrants further consideration.*
● (red) = *High risk interaction: a key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

Figure 21.5-1

Conceptual Model for Potential Human Receptor Exposure to Contaminants of Potential Concern



Notes: Green arrows indicate routes of transport from source to media.
Blue arrows indicate routes of exposure from media to intermediate receptor.
Red arrows indicate exposure pathways to human receptor.

Human receptors for the air quality human health assessment are people that either temporarily or permanently reside in the LSA and RSA, such as people using the snowmobile cabins and campgrounds; transient or recreational land users who may fish, hunt, or collect berries and other plants near the Project Site; people residing in Vavenby and Birch Island; and off-duty workers at the workers' camp during Construction. There are 165 human health receptor locations within the air quality model domain (which is smaller than the human health RSA shown in Figure 21.3-1).

Direct exposure pathways exist from the sources of air emissions, such as fuel combustion exhaust from generators, equipment and machinery, vehicles, and helicopters, or fugitive dust from use of the access road and the handling and stockpiling of non-PAG waste rock and low grade ore, and overburden and topsoil stockpiles, to human receptors through the inhalation pathway (Figure 21.5-1).

As shown in Table 21.5-1, the majority of Project activities during the Construction and Operations phases interact with air quality; however, only low- or moderate-risk interactions are expected to occur. Emissions associated with Construction and Operations phases were calculated and input into the air quality model to determine air quality concentrations for particulate matter. More information on the sources included in the air quality model and the emissions predictions can be found in Chapter 9, Section 9.5.

As shown in Table 21.5-1, Project activities during the Closure phase interact with a number of indicators; however, only low-risk interactions are expected to occur. There are no interactions during Post-Closure. There will be limited emission sources during the Closure and Post-Closure phases, and therefore the air quality impacts are expected to be significantly less than those during the year with the highest emissions in the Construction and Operations phases.

The potential human health effects resulting from poor air quality involve the body's respiratory and cardiovascular systems and may range from subtle biological and physical changes to breathing difficulties, wheezing, coughing, and aggravation of existing respiratory and cardiac conditions. Individual reactions depend on the air pollutant, the degree of exposure, the individual's health status, and genetics. Although everyone is at risk from the health effects of air contaminants, certain individuals are more susceptible such as children, the elderly, and people with cardio-respiratory health problems (Health Canada 2009a).

Total suspended particles (TSP) larger than 10 µm in diameter are primarily deposited in the respiratory tract above the larynx and do not reach the lungs (WHO 2000). The evaluation of particulate air pollution has shifted focus from total TSP to the finer fractions of suspended particles ($PM_{2.5}$ and PM_{10}), as the smaller fractions are responsible for the observed adverse health effects (Health Canada 1999b; WHO 2000). Health Canada (1999b), the WHO (2000), and the US EPA (2012) no longer consider TSP in the evaluation of health effects from particles in air, and instead focus on $PM_{2.5}$ and PM_{10} as those particles can reach the thoracic area of the lungs (WHO 2000). Thus even though TSP concentrations were predicted by the air quality model, this human health effects assessment will only consider predicted concentrations of PM_{10} and $PM_{2.5}$.

$PM_{2.5}$ and PM_{10} pose a risk to human health as they can travel into and lodge themselves deeply in the lungs, depending on size of the particle. $PM_{2.5}$ in particular can cause coughing, breathing difficulties, reduced lung function, an increased use of asthma medication, can irritate the eyes and nose, and can cause lung cancer. $PM_{2.5}$ is recognized as a potential carcinogen. The US EPA (1999) revised draft Guidelines for Carcinogen Risk Assessment states that diesel exhaust is likely to be carcinogenic to humans by inhalation from environmental exposure. The WHO (2013) also recognizes the carcinogenic properties of particulate matter. However, neither Health Canada nor the US EPA has provided a quantitative estimate of carcinogenic inhalation risk (i.e., a slope factor) for diesel PM because of the absence of adequate data to develop a dose-response relationship from epidemiologic studies. In the absence of an inhalation slope factor, calculation of an ILCR is not possible; therefore, only potential non-carcinogen effects of $PM_{2.5}$ were assessed.

21.5.1.2 Country Foods Quality

The purpose of the country foods effects assessment is to evaluate the potential for Project activities to affect human health from the incidental consumption of contaminants in or on country foods. Since the proposed Project is a metal mine located in a mineralized area, the emphasis in the assessment is on metals. This is because, among contaminants, metals have the most potential to be present in the aquatic or terrestrial environment at levels high enough to affect human health (via country foods consumption) in the LSA or RSA after mitigation is taken into consideration.

Metals occur naturally in environmental media (e.g., water, soil, and vegetation) due to local physical and geological processes, and their concentrations could potentially change due to Project activities. Because country foods can take up metals from environmental media, the quality of the foods is directly influenced by concentrations of contaminants in the media. Potential effects from the Project on the quality of county foods may occur due to changes in water quality (e.g., due to Project-related seepage or discharge) or due to changes in soil and vegetation quality (i.e., due to deposition of dust).

Table 21.5-1 shows the potential interactions between Project components or activities and country foods. The risk rating provided for each interaction is based on the risk rating conducted for air quality (Chapter 9, Table 9.5-1) and water quality (Chapter 13, Table 13.5-1), since these VCs can directly or indirectly affect the quality of country foods. The risk rating assigned for country foods is based on the highest rating assigned for either air quality or water quality. For example, if the air quality risk rating for interaction with a particular Project component or activity is “yellow”, but it is rated as “red” for water quality, the “red” rating is also used for country foods.

Changes in water quality due to the Project were assessed in Chapter 13 (Section 13.5.1 and 13.5.2) and considered the following:

- erosion and sedimentation;
- dust deposition onto surface water; and
- changes in chemical concentration due to metal leaching from disturbed areas, groundwater seepage, or discharge from the TMF to T Creek.
- changes in soil or vegetation quality through deposition of fugitive dust or other air contaminants may occur due to:
- construction activities (e.g., such as construction of camps and infrastructure, clearing vegetation, and stripping top soil);

- incinerator use;
- drilling, blasting, extraction, and hauling material;
- crushing, conveyance, and ore processing; and
- access road widening, culvert installation, maintenance, and use.

Atmospheric Project emissions have the potential to enter the air and be transported some distance from the source. While it is possible that wildlife (e.g., moose and other terrestrial organisms) could take up contaminants directly from air inhalation, this pathway is considered to be a very minor source of contaminants compared to uptake through the diet (Sample et al. 1997; BC MOE 2013g). Therefore, exposure of country foods to contaminants via the inhalation route has been excluded from further consideration in wildlife harvested as country foods; the primary exposure pathway to Project-related contaminants is via the food chain. Dust deposition rates can be used as an indication of the potential for exposure of soils and vegetation to dust-associated contaminants, including metals.

Toxicity to humans from ingesting country foods can result in a variety of health effects depending on the individual contaminant, and effects may range from carcinogenic effects to non-carcinogenic effects (e.g., changes in physiological functions or systems). Metals can disturb biochemical processes and normal body functions and involve many body organ systems such as neurological, cardiovascular, immunological, hematological, gastrointestinal, and musculoskeletal systems. However, toxicity in human consumers of country foods will only occur if sufficiently high concentrations of contaminants are taken in, such that toxicity thresholds are surpassed. The potential for effects to humans due to contaminants that may be present in country foods depends on a number of factors such as:

- the developmental stage of the human receptor (i.e., adult, toddler, women of child-bearing age);
- the toxicity of the contaminant;
- the speciation of the metal;
- bioavailability;
- whether the body is able to efficiently eliminate the contaminant;
- whether the contaminant can bioaccumulate;
- the amount of country food that is consumed (dose and frequency of consumption); and
- the period of time that wildlife or fish spend in the area (influences the concentration of metal in the tissues consumed).

Note that the potential for spills and accidents involving large quantities of water, chemicals, tailings, and sediment are not considered here as these are related to occurrences of low likelihood outside of normal operating conditions. These occurrences are addressed in Chapter 26 (Environmental Effects of Accidents and Malfunctions) as well as in the Spill Prevention and Response Plan (Section 24.15).

21.5.1.3 Drinking Water Quality

The purpose of the drinking water quality effects assessment is to evaluate the potential for Project activities to affect human health from drinking water (Figure 21.5-1). The assessment of key effects to human health from drinking water relies on the baseline surface water quality information collected between 2007 and 2014 (Appendix 13-B), baseline groundwater quality information collected in 2013 and 2014 (Appendix 11-A), and the Project-related surface water quality predictions as presented in Chapter 13 and Appendix 13-C. All surface water quality model assumptions are presented in Appendix 13-C. The pathways through which surface water quality could be affected by the Project are described in Chapter 13, Section 13.5.1. Pathways include changes in water quality due to erosion and sedimentation, dust deposition, or changes in chemical concentrations due to loading from Project components or activities. Table 21.5-1 shows the potential interactions between Project components or activities and drinking water quality. The risk rating provided for each interaction is based on the risk rating conducted for hydrogeology (Chapter 11, Table 11.5-1) and surface water quality (Chapter 13, Table 13.5-1), since these VCs can directly or indirectly affect the quality of drinking water. The most significant risk ratings (shown as "red" dots), are associated with Project components or activities that are most likely to change the quality of drinking water in terms of metal or ion concentrations.

Although no specific surface waterbodies or springs within the LSA or RSA were identified as drinking water sources for transient use during land use or traditional knowledge studies, it is assumed for the purpose of this assessment that surface water could occasionally be used by people (e.g., trappers, hunters, and recreational users) for drinking while travelling within the LSA and RSA. The LSA and RSA are within driving distance from Vavenby, Clearwater, and Barriere, and land users are likely to bring drinking water from the community water systems or bottled water for day use. However, it is possible that people may stay at campsites multiple days and may drink untreated surface water. Health Canada recommends that water collected from surface waterbodies always be treated before drinking (Health Canada 2008), because surface water can contain naturally occurring bacteria, viruses, and protozoa. Land users may have limited access to water purification systems and may consume untreated water. Generally, personal water purification systems are not designed to treat metals or other chemicals.

As water moves through wetlands, forests, and riparian areas, certain contaminants (e.g., metals, viruses, oils, and excess nutrients) are absorbed and filtered out of the water by soil and organisms (Ecological Society of America and the Union of Concerned Scientists 2014). Examples of natural ecosystem processes are: bacteria that use or break down contaminants, vegetation in wetlands and riparian areas that take up metals, and sediment in wetlands that absorb metals acting as contaminant sinks. This can decrease the concentrations of contaminants that may be present in environments downstream of potential sources. Natural ecosystem processes that treat and filter water will be affected by the proposed Project (e.g., loss of wetlands in and around the TMF footprint; see Chapter 15, Terrestrial Ecology Effects Assessment), however, the implications are likely to be minimal when considering lotic environments such as T Creek or Harper Creek where the potential for attenuation of metals is lower. The surface water quality model (described in Chapter 13 and Appendix 13-C) did not include the attenuation of contaminants by natural ecosystem processes, thus the model is likely to be conservative in this regard.

Potential human health effects from drinking surface water with elevated contaminant concentrations depend on a number of factors such as:

- the concentration and toxicity of the contaminant;
- speciation of the metal;
- bioavailability;
- whether the body is able to efficiently eliminate the contaminant;
- whether the contaminant can bioaccumulate;
- the amount of water that is consumed (a function of both time and quantity); and
- the period of time that a person spends in the area.

Toxicity from metals can result in a variety of health effects depending on the individual contaminant. Metals can disturb biochemical processes and normal body functions and involve many body organ systems such as neurological, cardiovascular, immunological, hematological, gastrointestinal, and musculoskeletal systems. However, toxicity will only occur if humans drink enough water with sufficiently high concentrations of contaminants, such that toxicity thresholds are surpassed. Note that the potential for spills and accidents involving large quantities of water, chemicals, tailings, and sediment are not considered here as these are related to occurrences of low likelihood outside of normal operating conditions. These occurrences are addressed in Chapter 26 (Environmental Effects of Accidents and Malfunctions) as well as in the Spill Prevention and Response Plan (Section 24.15).

21.5.1.4 Noise

Noise is defined as any undesirable sound that may irritate people, disturb rest or sleep, cause loss of hearing, or otherwise affect the quality of life of affected individuals (PWC Consulting 2002). Noise can result in psychological and physiological effects (e.g., stress), mental health effects, and effects on residential behaviour (WHO 1999). Noise effects on public health (this chapter), wildlife (Chapter 16), recreational land users (Chapter 18) and traditional land users (Chapter 22) will be assessed based on recommended levels from various jurisdictions or literature (Section 10.5.1.3).

The Construction, Operations, Closure, and Post-Closure phases of the Project will emit noise from haul trucks and open-pit mining activities. Noise from mining activity will be almost continuous, specifically in the areas adjacent to the pits and the process plant. Closure and Post-Closure noise levels will be lower, intermittent, and related to decommissioning activities, treatment, or reclamation and maintenance.

A scoping exercise was conducted in order to explore potential Project interactions with Project components and activities in order to identify the key potential adverse noise effects. Table 21.5-1 provides risk ratings of Project effects on noise with green indicating low risk interaction, yellow indicating moderate risk interaction, and red indicating high risk interaction. This risk rating analysis is based on the potential interaction between Project components and activities with noise identified in Table 21.3-2. Noise has the potential to affect human health, as described in the following sections.

Sleep Disturbance

Uninterrupted sleep is required for normal physiological and mental functioning; however, environmental noise commonly causes sleep disturbance (WHO 1999). Symptoms of sleep disturbance include: difficulty falling asleep; awakenings and alterations of sleep stages or depth; increased blood pressure, heart rate and finger pulse amplitude; vasoconstriction; changes in respiration; cardiac arrhythmia; and increased body movements (WHO 1999). There are also secondary/after-effects of sleep disturbance which occur the following morning or day(s) including: reduced perceived sleep quality; increased fatigue; depressed mood or well-being; and decreased performance (WHO 1999).

Interference with Speech Communication

Speech interference occurs when noise levels are high enough that the ability to understand speech is impaired (WHO 1999). Auditory communication is important to human health as it can be used to signal things such as door bells, telephones, alarm clocks, fire alarms, and occupational task sounds. Vehicle pass-by can contribute to speech interference and therefore was included as a source in the assessment.

Noise and Vibration from Blasting

Blasting has potential to cause noise and vibration impacts on human receptors in terms of either nuisance or discomfort. Blasting from mining activities can have effects on nearby residential areas (e.g., Vavenby and Barriere) with regard to ground-borne vibration and air-blast overpressure events.

Ground-borne vibration from blasting is the radiation of mechanical energy within a rock mass or soil. It comprises various vibration phases travelling at different velocities. These phases are reflected, refracted, attenuated and scattered within the rock mass or soil, so that the resulting ground vibration at any particular location will have a complex character with various peaks and frequency content. Typically, higher frequencies are attenuated rapidly so that at close distances to the source such frequencies will be present in greater proportion than at far distances from the source.

Air-blast is the pressure wave (sound) produced by the blast and transmitted through the air. Unlike ground vibration there is only one air-blast phase and it is a complex wave-train consisting of various peaks and with a range of frequencies.

It is recognized that air-blast overpressure and ground-borne vibration produced by blasting falls into two categories, which are considered in the effects assessment:

- those causing human discomfort; and
- those with the potential for causing damage to structures, architectural elements and services.

Annoyance

The response to noise is subjective and is affected by many factors such as the difference between the specific sound (sound from the Project) and the residual sound (noise in the absence of the specific sound), characteristics of the sound (e.g., if it contains tones, impulses), absolute level of sound, time of day, local attitudes to the Project, and expectations for quiet. An increase in noise levels may be associated with an increase in annoyance of the population exposed to the noise. Health Canada (2010e) suggested that annoyance be considered as "an appropriate indicator of noise-induced human health effects for project operational noise and for long-term construction noise exposure."

Metrics Not Included in the Assessment

Complaints

The likelihood of a complaint is directly linked to the ability or willingness of an individual to make a complaint and his or her expectation that the complaint will result in noise reduction. Therefore, there is not always a strong link between the disturbance and the complaint. However, widespread complaints can be expected if the noise level is high.

Although the likelihood of a complaint is subjective, widespread complaints have been found to be more likely above an L_{dn} of 62 dBA and vigorous community action should be expected if the Project L_{dn} is greater than 75 dBA (US EPA 1974).

Day-night sound level L_{dn} is the A-weighted equivalent sound level for a 24-hour period with an additional 10 dBA imposed on the equivalent sound level for nighttime hour (L_n). Since the criterion for L_d used in this assessment is 55 dBA, and the criterion for L_n used in the assessment is 45 dBA, with the 10 dBA penalty added to the nighttime L_n, L_{dn} will not exceed 62 dBA. Therefore, using L_d of 55 dBA and L_n of 45 dBA is deemed sufficient for the assessment and L_{dn} criteria of 62 dBA and 75 dBA are not used.

21.5.2 Mitigation Measures

The following sections detail mitigation and management measures designed to reduce or eliminate adverse Project effects. Mitigation measures that are recommended to reduce an adverse effect are technically, environmentally, and economically feasible, and aim to avoid, reduce, control, eliminate, or offset potential Project effects. The Project has been designed to reduce adverse effects by optimizing alternatives, incorporating specific design changes, following best practices, and enhancing project benefits.

Mitigation methods may include measures for ongoing communications with the public regarding potential public health risks if they arise. It is expected that the mitigation measures and monitoring described below (as well as in the management plans in Chapter 24) will minimize potential public health risks.

The mitigation methods which will be implemented are listed in Table 21.5-2. The anticipated effectiveness of each mitigation measures is defined in Chapter 8 as follows.

- Low effectiveness: After implementation of the mitigation measure, there is still a major change in the indicator, VC, or discipline from the baseline condition.

- Moderate effectiveness: After implementation of the mitigation measure, there is a measurable change in the indicator, VC, or discipline from the baseline condition.
- High effectiveness: After implementation of the mitigation measure, there is no change in the indicator, VC, or discipline from the baseline (e.g., it returns to its original condition before the construction of the Project) or an environmental enhancement is evident.
- Unknown effectiveness: The suggested mitigation measure has not been tried elsewhere in similar circumstances and the response of the indicator, VC, or discipline compared to the baseline is unknown.

Table 21.5-2. Proposed Mitigation Measures and their Effectiveness

Valued Component			
Potential Effect	**Proposed Mitigation Measure**	**Mitigation Effectiveness** ***(Low/Moderate/High/ Unknown)***	**Residual Effect** ***(Y/N)***
Change in air quality affecting human health (due to increased air emissions or fugitive dust)	Air Quality Management Plan (Section 24.2)	Moderate (see Chapter 9, Table 9.5-13 for more information)	Yes
Change in country foods quality affecting human health	No hunting, fishing, or berry collecting at the Project Site.	High	Yes
	Mitigation measures to protect air, water, soil, and vegetation quality.	Moderate	Yes
Change in drinking water quality affecting human health	Mine Waste and ML/ARD Management Plan (Section 24.9); Fish and Aquatic Effects Monitoring and Management Plan (Section 24.6); Groundwater Monitoring and Management Plan (Section 24.8); Selenium Management Plan (Section 24.12); Soil Salvage and Storage Plan (Section 24.14); Site Water Management Plan (Section 24.13); Sediment and Erosion Control Plan (Section 24.11); Air Quality Management Plan (Section 24.2)	Moderate (see Chapters 11 and 13, Tables 11.5-2 and 13.5-2 for more information)	Yes
Increase in noise levels	Noise Management Plan (Section 24.10)	Moderate to High (see Chapter 10, Table 10.5-14 for more information)	Yes

21.5.2.1 Air Quality Mitigation

Mitigation measures for air quality are fully described in Chapter 9, Section 9.5.3 of the Application/EIS and in the Air Quality Management Plan (Section 24.2). Mitigation to reduce effects to human health from the inhalation of air contaminants relies on mitigation measures that reduce effects to air quality.

There are two main types of mitigation and management measures that will be put in place in order to reduce air quality impacts associated with the Project: emission reduction measures and fugitive dust reduction measures. The majority of measures will be relevant for all phases of the Project and for all pollutants. Emission reduction methods include implementing energy efficiency measures, installing emission control systems (e.g., wet scrubbers) on stacks and on relevant ventilation systems, and ensuring proper equipment maintenance. Fugitive dust suppression measures include wetting work areas and roads, installing covers on equipment and loads carried by vehicles, installing windbreaks or fences, and using dust hoods and shields.

21.5.2.2 Country Foods Mitigation

Mitigation measures proposed to protect environmental quality (i.e., air, soil, vegetation, or water quality) will also serve to minimize potential effects to the quality of country foods. Mitigation measures for air quality, such as mitigation to minimize fugitive dust emissions, were discussed in Chapter 9 and Chapter 24, Section 24.2. The objective of the Air Quality Management Plan (Section 24.2) is to establish measures to mitigate Project-related emissions and meet ambient air quality objectives and standards (CCME 1999; BC MOE 2013a; CCME 2013a).

Some potential exists for fuel spills and spills of other potentially harmful chemicals which will be transported to and from the Project Site and utilized at the Project. The Mine Waste and ML/ARD Management Plan (Section 24.9), Waste Management Plan (Section 24.18), Fuel and Hazardous Materials Management Plan (Section 24.7), Explosives Handing Plan (Section 24.5), Spill Prevention and Response Plan (Section 24.15), and Emergency Response Plan (Section 24.4) can be found in Chapter 24. Proper Storage, handing, and clean-up of any spills of fuels/petroleum products and potentially hazardous substances will reduce the potential for these products to affect human health due to consumption of country foods. Because spills will be contained and cleaned up according to the Spill Prevention and Response Plan (Section 24.15), the effects of fuel, lubricants, and other COPCs on country foods will be low. If such spills occur, the proponent will work with local authorities in monitoring any adverse effects that may occur in the affected area and will assist in notification of affected communities. Therefore, residual effects to human health from spills of fuels and lubricants are considered negligible and are not considered further.

Other management plans described in Chapter 24 that will contribute to minimizing the potential for change in the quality of country foods by minimizing effects to other VCs include:

- Air Quality Management Plan (Section 24.2)
- Fish and Aquatic Effects Monitoring and Management Plan (Section 24.6);
- Groundwater Monitoring and Management Plan (Section 24.8);
- Mine Waste and ML/ARD Management Plan (Section 24.9);
- Sediment and Erosion Control Plan (Section 24.11);
- Selenium Management Plan (Section 24.12);
- Site Water Management Plan (Section 24.13);
- Soil Salvage and Storage Plan (Section 24.14);

- Vegetation Management Plan (Section 24.17);
- Waste Management Plan (Section 24.18); and
- Wildlife Management Plan (Section 24.19).

Public access will be restricted along on-site roads through the Traffic and Access Management Plan (Section 24.16). In addition, a no hunting and gathering policy will be implemented for workers while present on site (Wildlife Management Plan, Section 24.19), which will reduce the potential for exposure to contaminants by minimizing the collection of country foods in areas closest to Project infrastructure (i.e., the areas in which there is the greatest potential for changes in the quality of country foods).

Adaptive management will be implemented, such that if monitoring and modelling indicate an unacceptable level of risk to human health additional mitigation measures will be implemented to decrease the risk. The Environmental Management and Monitoring Plans for the Project (Chapter 24) include monitoring of surface water quality, levels of metals and other COPCs in Project-disturbed soils, and vegetation tissue metal concentrations. If the concentrations of metals or other COPCs are shown to increase over time in water, soils, or vegetation due to mine activities, the need for a country foods risk assessment will be considered as part of the adaptive management strategy.

Risk Perception

The AIR for the Project (BC EAO 2011) requires that the perceived risk of consuming fish and wildlife located within and/or adjacent to the Project Site must be included in the Application/EIS. Public perception of risk is not 'irrational' in relation to expert or quantitative assessment; rather, it is based on alternative rationalities and knowledge. Risk perception is influenced by trust in experts and authorities and perceived risks are decreased where individuals feel a loss in the sense of control. Communication between the proponent and First Nations groups needs to be bi-directional and continuous for management of perceived risks to be successful.

Whether or not there are real or substantial changes to the quality of country foods, literature has been published on the impact of perceived effects to country foods due to mining activities, which can alter Aboriginal use of areas thought to be contaminated by a mine (Pufall et al. 2011). A study conducted by Poirier and Brooke (2000) among the Inuit of the Eastern Arctic, however, showed that the possible presence of contaminants was not appreciably modifying the methods used by the Inuit to hunt, prepare, and eat their food. Some short-term changes were reported, but did not persist. The Inuit remained confident in their ability to distinguish what was edible.

The Project proponent will engage in ongoing, open, two-way communication about perceived risks with Aboriginal groups, seeking to understand and mitigate these risks from the perspectives of Aboriginal groups and on the basis of traditional knowledge, wherever possible. Potential strategies include providing results of environmental monitoring programs (e.g., for aquatic or terrestrial environments) to Aboriginal groups, or including Aboriginal groups in design and implementation of monitoring programs. Any risks identified through environmental monitoring programs will be communicated to Aboriginal groups (in addition to any reporting requirements to regulatory agencies).

21.5.2.3 Drinking Water Mitigation

Mitigation to reduce effects to human health from ingestion of drinking water relies on mitigation measures that reduce the potential for effects to surface water and groundwater quality. The Project has been designed with the goal to minimize effects on water quality. Mitigation measures for surface water quality were described in Chapter 13, Section 13.5.3 of this Application/EIS. Mitigation measures for groundwater quality were described in Chapter 11, Section 11.5.2 and in the Groundwater Management Plan (Section 24.8). These mitigation measures include the following elements.

- Specific Project designs including a variety of diversion, collection, and storage/settlement structures to manage water. Non-contact water will be diverted and contact water will be collected and re-used in the mill plant and TMF to minimize water discharged to the environment. Details can be found in the Site Water Management Plan (Section 24.13).
- Implementation of seepage reduction and control measures and sub-aqueous disposal of PAG waste rock into the TMF, to reduce potential effects to groundwater quality (Section 11.5.2.2 and Groundwater Management Plan, Section 24.8).
- The Sediment and Erosion Control Plan (Section 24.11) will minimize the potential for Project-related introduction of total suspended solids into surface water, and the Soil Salvage and Storage Plan (Section 24.14) will do the same to prevent soil entering surface water.
- The Mine Waste and ML/ARD Management Plan (Section 24.9) will ensure that handling of materials minimizes the potential for metal mobilization into the aquatic environment.
- The Air Quality Management Plan (Section 24.2) includes measures to reduce air emissions, including controls to minimize the generation of fugitive dust and an Explosives Handling Plan (Section 24.5).
- Fish and Aquatics Effects Monitoring and Management Plan (Section 24.6).
- Selenium Management Plan (Section 24.12).
- Effluent and solids from sewage treatment plants will be treated and handled so that surface or groundwater sources are not impacted, in accordance with the BC Municipal Wastewater Regulation (B.C. Reg 87/2012). In addition, provision of potable water by the proponent at the Project site must be compliant with the requirements of the BC *Drinking Water Protection Act* (2001) and Drinking Water Protection Regulation (BC Reg. 200/2003). More details are available in the Waste Management Plan (Section 24.18).

Mitigation measures are also proposed to minimize the potential for effects to water quality due to spills.

21.5.2.4 Noise Mitigation

Noise mitigation measures are discussed in detail in Chapter 10, Section 10.5.3. There are three main mitigation strategies for noise control: controlling noise at the source, controlling the noise pathway, and controlling noise at the receptor. These noise mitigation strategies should follow a hierarchy of control, with source control always the preferred option where reasonable and feasible, and control at the receptor the least favourable option.

A Noise Management Plan (Section 24.10) has been developed to provide measures to control the noise sources (i.e., to reduce the overall noise from the Project).

21.5.3 Characterization and Likelihood of Residual Effects

21.5.3.1 Effects on Human Health due to Air Quality

Methodology for Assessing Effects to Human Health due to Air Quality

To assess residual effects to human health from changes in air quality due to Project-related emissions, future Project-related air quality was modelled. The methodology and assumptions used in the air quality dispersion model and the results are described in Chapter 9, Section 9.5.

The air quality model provided predictions for 24-hour averaging period concentrations for PM_{10}, and 24-hour and annual averaging period concentrations for $PM_{2.5}$. The model predictions were compared to BC AAQOs (BC MOE 2013a), shown in Table 21.5-3. If predicted CAC concentrations were lower than the BC AAQOs at a particular receptor location, no risk to human receptors at that location would be expected. If a predicted CAC was greater than the guideline limit, it would be considered a residual effect on human health due to air quality at that particular receptor location.

As noted previously, on-duty worker health and safety was not considered because the proponent must adhere to occupational health and safety requirements to ensure provision of a safe working environment (Sections 21.1 and 21.3.2.3). Thus, mine workers are only assessed in this Application/ EIS while off duty at night during the Construction phase, when they will be sleeping at the temporary construction camp.

Assessment of Residual Effects to Human Health due to Air Quality

The effects assessment for air quality described in Chapter 9 (Section 9.5.3) concluded that the effects would be not significant (moderate). Predicted dustfall, TSP, and PM_{10} concentrations were greater than the BC AAQOs along roads in some areas. Although it is possible that a person may pass through areas where air quality does not meet the BC AAQOs, it is unlikely that a recreational user or country foods harvester would spend 24-hours (or more) adjacent to the road during the occasions when dust or particulate concentrations are high. Thus, the potential exposure times at these locations are likely to be less than 24-hours and human health is unlikely to be affected by short-term, transient exposure that may occur in the affected areas; therefore, these predictions are not considered further in this chapter.

Concentrations of CACs were modelled for the specific human health receptor locations, shown on Figure 21.3-1. Air quality predictions at specific human receptor locations during the Construction and Operations phases are shown in Table 21.5-3.

Table 21.5-3. Predicted Air Quality during Construction and Operations Phases

Receptor Name	Receptor Type	UTM Zone 11		Construction			Operations		
		Easting	Northing	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)
Birch Island Campground	Campground	299137	5721100	9.51	3.28	3.22	10.1	3.32	3.23
Saskum Lake South	Campground	312519	5697881	9.15	3.25	3.21	9.34	3.26	3.21
Devost	Domestic Well	305119	5717716	10.1	3.39	3.25	11.5	3.78	3.34
Howatt	Domestic Well	305882	5717607	10.2	3.48	3.27	13.2	4.15	3.40
Moilliet	Domestic Well	307451	5717590	12.0	3.81	3.32	21.1	5.44	3.63
Moilliet North	Domestic Well	307407	5717808	12.2	3.84	3.33	21.9	5.54	3.68
Rothwell	Domestic Well	305504	5717539	10.1	3.42	3.26	12.1	3.92	3.36
Teatro	Domestic Well	304942	5717554	10.3	3.39	3.25	11.5	3.74	3.33
Birch Island Campground Water Station	Groundwater Licence (BC HA)	298754	5720869	9.53	3.28	3.21	10.0	3.30	3.22
Walker Road Water Station	Groundwater Licence (BC HA)	298627	5721045	9.49	3.27	3.21	10.0	3.30	3.22
R_330	House in Vavenby	310798	5718263	16.3	4.46	3.62	37.5	7.84	4.84
R_383	House in Vavenby	310989	5718071	17.6	4.91	3.72	42.2	9.43	5.21
R_409	House in Vavenby	311030	5718089	16.8	4.50	3.70	39.4	7.92	5.15
R_433	House in Vavenby	310984	5718164	16.2	4.53	3.66	36.9	8.10	5.01
R_458	House in Vavenby	310979	5718201	15.4	4.42	3.57	33.7	7.71	4.63
R_475	House in Vavenby	310630	5718252	17.9	5.16	3.82	43.7	10.6	5.69
R_476	House in Vavenby	310689	5718258	17.3	4.68	3.70	41.4	8.77	5.18
R_477	House in Vavenby	310720	5718251	16.2	4.73	3.67	37.2	8.77	5.03
R_478	House in Vavenby	310764	5718259	17.4	4.80	3.69	42.1	9.16	5.15
R_479	House in Vavenby	310839	5718256	15.8	4.39	3.62	35.4	7.58	4.85
R_482	House in Vavenby	310981	5718242	14.9	4.45	3.65	32.1	7.71	4.96
R_500	House in Vavenby	310871	5718278	17.1	4.67	3.74	40.4	8.61	5.38
R_501	House in Vavenby	310917	5718275	16.1	4.54	3.66	36.7	8.13	5.05

(continued)

Table 21.5-3. Predicted Air Quality during Construction and Operations Phases (continued)

Receptor Name	Receptor Type	UTM Zone 11		Construction			Operations		
		Easting	Northing	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)
R_502	House in Vavenby	310975	5718288	17.4	4.94	3.87	41.4	9.63	5.84
R_503	House in Vavenby	311016	5718297	17.8	4.67	3.78	43.1	8.64	5.48
R_569	House in Vavenby	310970	5718551	16.7	4.36	3.57	39.0	7.42	4.64
Rail Concentrate Load-out Area	Infrastructure	308063	5718478	15.2	4.34	3.62	33.4	7.47	4.93
Temporary Construction Camp	Minesite	305481	5710050	175	18.7	5.99	NA	NA	NA
Lower Pullout Area	Potential Pullout Area for Snowmobile	311495	5714641	14.1	3.53	3.30	15.0	3.61	3.33
Upper Pullout Area	Potential Pullout Area for Snowmobile	308347	5710523	41.8	6.56	3.80	77.3	10.5	4.19
Foghorn Mountain Cabin	Snowmobile Cabin	296085	5711643	10.3	3.42	3.23	11.5	3.44	3.24
Harp Mountain Cabin	Snowmobile Cabin	306055	5704091	13.4	3.58	3.26	16.0	3.62	3.25
Vavenby Mountain Cabin	Snowmobile Cabin	313089	5712035	10.8	3.42	3.26	12.6	3.55	3.28
Birch Island Water Station	Surface Water Licence (BC HA)	297349	5720867	9.52	3.27	3.21	10.1	3.30	3.22
Vavenby Community Water Station	Surface Water Licence (BC HA)	310689	5717898	12.6	3.80	3.35	23.1	5.35	3.75
C021998	Surface Water Licence (BC MFLNRO)	300169	5718720	9.80	3.31	3.22	10.6	3.42	3.25
C035240 and C046138	Surface Water Licence (BC MFLNRO)	310704	5717905	12.6	3.81	3.36	23.1	5.37	3.75
C035996	Surface Water Licence (BC MFLNRO)	309017	5719499	10.1	3.39	3.26	12.0	3.78	3.36
C036251, C036252, C036257, C036258, C036469, and C056116	Surface Water Licence (BC MFLNRO)	311622	5718304	11.7	3.60	3.33	19.7	4.68	3.62

(continued)

Table 21.5-3. Predicted Air Quality during Construction and Operations Phases (continued)

Receptor Name	Receptor Type	UTM Zone 11		Construction			Operations		
		Easting	Northing	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)
C036557	Surface Water Licence (BC MFLNRO)	304028	5719498	9.85	3.32	3.23	10.7	3.52	3.27
C037012	Surface Water Licence (BC MFLNRO)	307198	5719449	9.76	3.37	3.25	11.6	3.70	3.34
C037861 and C039573	Surface Water Licence (BC MFLNRO)	303943	5719340	9.88	3.33	3.23	10.7	3.53	3.28
C038732	Surface Water Licence (BC MFLNRO)	308405	5717569	12.4	3.83	3.34	22.3	5.52	3.69
C039912, C049737, and C130890	Surface Water Licence (BC MFLNRO)	303618	5719509	9.90	3.32	3.23	10.7	3.51	3.27
C047236	Surface Water Licence (BC MFLNRO)	313988	5718653	9.93	3.33	3.24	10.7	3.49	3.29
C051299, C051300, and F006786	Surface Water Licence (BC MFLNRO)	315208	5719870	9.45	3.29	3.23	10.2	3.43	3.28
C051728	Surface Water Licence (BC MFLNRO)	301845	5720396	9.74	3.30	3.22	10.3	3.41	3.25
C055396	Surface Water Licence (BC MFLNRO)	315053	5721034	9.44	3.31	3.24	10.8	3.56	3.32
C055685	Surface Water Licence (BC MFLNRO)	306232	5718944	10.0	3.40	3.26	13.5	3.91	3.37
C055686	Surface Water Licence (BC MFLNRO)	306868	5718821	10.5	3.50	3.27	15.3	4.28	3.45
C055687	Surface Water Licence (BC MFLNRO)	306656	5718880	10.3	3.46	3.27	14.6	4.18	3.42
C057254	Surface Water Licence (BC MFLNRO)	301787	5717913	9.87	3.35	3.23	10.7	3.49	3.27
C059847	Surface Water Licence (BC MFLNRO)	300145	5720821	9.58	3.29	3.22	10.1	3.35	3.24

(continued)

Table 21.5-3. Predicted Air Quality during Construction and Operations Phases (continued)

Receptor Name	Receptor Type	UTM Zone 11		Construction			Operations		
		Easting	Northing	PM_{10} 24-hour Concentration (μg/m³)	$PM_{2.5}$ 24-hour Concentration (μg/m³)	$PM_{2.5}$ Annual Concentration (μg/m³)	PM_{10} 24-hour Concentration (μg/m³)	$PM_{2.5}$ 24-hour Concentration (μg/m³)	$PM_{2.5}$ Annual Concentration (μg/m³)
C059932, C059933, and C059937	Surface Water Licence (BC MFLNRO)	310263	5717790	12.4	3.73	3.35	22.4	5.17	3.73
C063625	Surface Water Licence (BC MFLNRO)	313369	5717830	11.4	3.44	3.27	12.1	3.58	3.32
C067014	Surface Water Licence (BC MFLNRO)	301742	5719594	9.83	3.31	3.23	10.5	3.43	3.25
C067204	Surface Water Licence (BC MFLNRO)	316890	5718822	9.37	3.27	3.22	9.70	3.32	3.24
C067204	Surface Water Licence (BC MFLNRO)	316888	5718640	9.37	3.27	3.22	9.70	3.32	3.24
C102945	Surface Water Licence (BC MFLNRO)	310877	5717844	12.8	3.83	3.35	23.7	5.42	3.71
C104262 and C104264	Surface Water Licence (BC MFLNRO)	304792	5719949	9.83	3.31	3.23	10.6	3.48	3.28
C104263	Surface Water Licence (BC MFLNRO)	304806	5719813	9.85	3.32	3.23	10.6	3.49	3.28
C104561	Surface Water Licence (BC MFLNRO)	310647	5717939	12.8	3.84	3.37	23.8	5.49	3.81
C108103 and C109930	Surface Water Licence (BC MFLNRO)	307254	5719364	9.79	3.38	3.25	11.9	3.75	3.35
C112429	Surface Water Licence (BC MFLNRO)	301559	5720022	9.76	3.30	3.22	10.4	3.42	3.25
C118494 to C118511	Surface Water Licence (BC MFLNRO)	297360	5720872	9.52	3.27	3.21	10.1	3.30	3.22
C120348	Surface Water Licence (BC MFLNRO)	306523	5719725	9.77	3.33	3.24	10.5	3.61	3.31
F018324	Surface Water Licence (BC MFLNRO)	307934	5717102	12.1	3.52	3.28	21.1	4.29	3.46

(continued)

Table 21.5-3. Predicted Air Quality during Construction and Operations Phases (continued)

Receptor Name	Receptor Type	UTM Zone 11		Construction			Operations		
		Easting	Northing	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)
F068312	Surface Water Licence (BC MFLNRO)	297360	5720872	9.52	3.27	3.21	10.1	3.30	3.22
F053068	Surface Water Licence (BC MFLNRO)	297742	5722728	9.35	3.26	3.21	9.75	3.28	3.22
C037465	Surface Water Licence (BC MFLNRO)	292993	5721702	9.30	3.25	3.21	9.59	3.27	3.21
C130441	Surface Water Licence (BC MFLNRO)	297296	5720849	9.52	3.27	3.21	10.1	3.30	3.22
Serenity Performing Arts Centre	Tourism Facility	305242	5717688	10.1	3.41	3.26	11.7	3.83	3.35
Vavenby Trail Rides	Tourism Facility	305677	5718889	9.78	3.38	3.25	12.3	3.75	3.33
Birch Island	Town	298009	5720581	9.59	3.28	3.21	10.1	3.31	3.22
Vavenby	Town	311789	5718194	11.7	3.62	3.33	19.7	4.66	3.62
68	Well (BC MOE)	303840	5718969	9.97	3.34	3.23	10.9	3.54	3.28
56016	Well (BC MOE)	298417	5719970	9.62	3.28	3.22	10.2	3.32	3.23
56018	Well (BC MOE)	298494	5720146	9.60	3.28	3.22	10.2	3.31	3.23
56022	Well (BC MOE)	304818	5718638	9.94	3.35	3.24	11.2	3.61	3.30
56024	Well (BC MOE)	304540	5718582	9.97	3.34	3.24	11.0	3.51	3.28
56025	Well (BC MOE)	305262	5718922	9.82	3.36	3.24	11.6	3.64	3.31
56032	Well (BC MOE)	307290	5717678	11.9	3.76	3.32	20.7	5.22	3.62
56035	Well (BC MOE)	307242	5719195	9.85	3.39	3.26	12.6	3.87	3.38
56043	Well (BC MOE)	298772	5721192	9.49	3.27	3.21	10.1	3.31	3.23
56045	Well (BC MOE)	298768	5721268	9.49	3.27	3.21	10.0	3.31	3.23
C120388	Surface Water Licence (BC MFLNRO)	303564	5719127	10.0	3.34	3.23	10.9	3.52	3.27

(continued)

Table 21.5-3. Predicted Air Quality during Construction and Operations Phases (continued)

Receptor Name	Receptor Type	UTM Zone 11		Construction			Operations		
		Easting	Northing	PM_{10} 24-hour Concentration (µg/m^3)	$PM_{2.5}$ 24-hour Concentration (µg/m^3)	$PM_{2.5}$ Annual Concentration (µg/m^3)	PM_{10} 24-hour Concentration (µg/m^3)	$PM_{2.5}$ 24-hour Concentration (µg/m^3)	$PM_{2.5}$ Annual Concentration (µg/m^3)
C122585	Surface Water Licence (BC MFLNRO)	313112	5723393	9.73	3.30	3.24	10.3	3.45	3.29
C124889	Surface Water Licence (BC MFLNRO)	312415	5717648	27.8	5.06	3.81	31.5	5.40	3.95
C129165	Surface Water Licence (BC MFLNRO)	298114	5722389	9.39	3.26	3.21	9.85	3.29	3.22
C130441	Surface Water Licence (BC MFLNRO)	297360	5720872	9.52	3.27	3.21	10.1	3.30	3.22
C130960	Surface Water Licence (BC MFLNRO)	312396	5717971	10.8	3.39	3.26	12.1	3.69	3.34
C130960	Surface Water Licence (BC MFLNRO)	312329	5717983	11.0	3.40	3.27	12.3	3.73	3.35
F005554	Surface Water Licence (BC MFLNRO)	309883	5716838	10.7	3.41	3.26	12.5	3.76	3.34
F006784	Surface Water Licence (BC MFLNRO)	315191	5719843	9.45	3.29	3.23	10.2	3.43	3.28
F009831	Surface Water Licence (BC MFLNRO)	313160	5718645	9.98	3.35	3.25	11.3	3.63	3.33
F017448	Surface Water Licence (BC MFLNRO)	299259	5721665	9.45	3.27	3.21	9.93	3.31	3.23
59636	Well (BC MOE)	304690	5718694	9.95	3.35	3.24	11.1	3.59	3.30
83731	Well (BC MOE)	304079	5718933	9.93	3.34	3.23	10.9	3.56	3.28
84684	Well (BC MOE)	303948	5719079	9.92	3.33	3.23	10.8	3.55	3.28
84685	Well (BC MOE)	304155	5719073	9.93	3.34	3.24	10.9	3.56	3.29
84693	Well (BC MOE)	303576	5718980	10.0	3.34	3.23	11.0	3.52	3.28
85732	Well (BC MOE)	298282	5720911	9.56	3.27	3.21	10.1	3.30	3.22
85785	Well (BC MOE)	309205	5718842	11.1	3.61	3.31	17.4	4.69	3.60

(continued)

Table 21.5-3. Predicted Air Quality during Construction and Operations Phases (continued)

Receptor Name	Receptor Type	UTM Zone 11		Construction			Operations		
		Easting	Northing	PM_{10} 24-hour Concentration (μg/m³)	$PM_{2.5}$ 24-hour Concentration (μg/m³)	$PM_{2.5}$ Annual Concentration (μg/m³)	PM_{10} 24-hour Concentration (μg/m³)	$PM_{2.5}$ 24-hour Concentration (μg/m³)	$PM_{2.5}$ Annual Concentration (μg/m³)
86445	Well (BC MOE)	310342	5718503	12.7	4.00	3.45	23.7	6.12	4.17
86777	Well (BC MOE)	307840	5718119	14.4	4.44	3.46	30.3	7.89	4.23
89601	Well (BC MOE)	298825	5720969	9.51	3.27	3.21	10.0	3.30	3.22
89661	Well (BC MOE)	298727	5720241	9.65	3.28	3.22	10.1	3.31	3.23
89708	Well (BC MOE)	298468	5722067	9.43	3.26	3.21	9.89	3.29	3.22
90211	Well (BC MOE)	303095	5719092	10.1	3.33	3.23	11.0	3.50	3.27
90213	Well (BC MOE)	298398	5721002	9.53	3.27	3.21	10.0	3.30	3.22
96276	Well (BC MOE)	310689	5717634	11.5	3.64	3.31	19.0	4.73	3.55
98246	Well (BC MOE)	298637	5720106	9.61	3.28	3.22	10.2	3.32	3.23
98348	Well (BC MOE)	298055	5721752	9.46	3.26	3.21	9.93	3.29	3.22
98618	Well (BC MOE)	305899	5716256	10.4	3.44	3.26	11.8	3.61	3.31
98622	Well (BC MOE)	305310	5717233	10.2	3.42	3.26	11.6	3.76	3.34
100129	Well (BC MOE)	315137	5721120	9.46	3.31	3.24	10.8	3.55	3.32
100189	Well (BC MOE)	304015	5718797	9.96	3.34	3.23	10.9	3.52	3.28
104221	Well (BC MOE)	298569	5720088	9.61	3.28	3.22	10.2	3.32	3.23
104225	Well (BC MOE)	298562	5720005	9.61	3.28	3.22	10.2	3.32	3.23
106859	Well (BC MOE)	316859	5718881	9.38	3.27	3.22	9.70	3.32	3.24
106863	Well (BC MOE)	299218	5720840	9.50	3.27	3.21	10.0	3.30	3.22
108071	Well (BC MOE)	298607	5720929	9.58	3.27	3.21	10.0	3.30	3.22
108073	Well (BC MOE)	298276	5721022	9.54	3.27	3.21	10.1	3.30	3.22
108074	Well (BC MOE)	298318	5720980	9.54	3.27	3.21	10.1	3.30	3.22
108114	Well (BC MOE)	307066	5719148	9.88	3.41	3.26	12.8	3.93	3.39
108120	Well (BC MOE)	298530	5720987	9.56	3.27	3.21	10.1	3.30	3.22
109191	Well (BC MOE)	307123	5719143	9.86	3.40	3.26	12.7	3.92	3.39

(continued)

Table 21.5-3. Predicted Air Quality during Construction and Operations Phases (completed)

Receptor Name	Receptor Type	UTM Zone 11		Construction			Operations		
		Easting	Northing	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)	PM_{10} 24-hour Concentration (µg/m³)	$PM_{2.5}$ 24-hour Concentration (µg/m³)	$PM_{2.5}$ Annual Concentration (µg/m³)
76186	Well (BC MOE)	296805	5720998	9.47	3.27	3.21	9.96	3.29	3.22
98353	Well (BC MOE)	297345	5722315	9.37	3.26	3.21	9.81	3.28	3.22
98653	Well (BC MOE)	296473	5723080	9.27	3.25	3.21	9.60	3.27	3.21
259	Well (BC MOE)	296811	5722721	9.32	3.26	3.21	9.69	3.27	3.22
77230	Well (BC MOE)	297245	5722537	9.35	3.26	3.21	9.76	3.28	3.22
100146	Well (BC MOE)	297340	5722308	9.37	3.26	3.21	9.81	3.28	3.22

Notes:
PM_{10} = particulate matter less than 10 µm in diameter, $PM_{2.5}$ = particulate matter less than 2.5 µm in diameter
BC HA = British Columbia Health Authority, BC MFLNRO = British Columbia Ministry of Forests, Lands and Natural Resource Operations, BC MOE = Ministry of Environment, NA = not applicable
Shading indicates the predicted concentration is greater than the BC Ambient Air Quality Objectives (BC MOE 2013a):

- *BC Ambient Air Quality Objective for 24-hour PM_{10} = 50 µg/m³*
- *BC Ambient Air Quality Objective for 24-hour $PM_{2.5}$ = 25 µg/m³*
- *BC Ambient Air Quality Objective for Annual $PM_{2.5}$ = 8 µg/m³*

Surface water licences C067204 and C130960 each have two records for domestic use purposes, which have different UTM coordinates, thus they appear twice in the list of human receptors.

During the Construction phase, the maximum predicted 24-hour concentration of PM_{10} was greater than the BC AAQO only at the temporary construction camp (Table 21.5-3 and Figure 1 in Appendix 21-C). Activities during the Construction phase will only occur during the day and the only emission sources at night are the generators and incinerator, thus concentrations at night will likely be lower than the BC AAQO. Furthermore the predicted concentrations are for 24-hour periods but the workers are only off-duty for 12 hours, thus the exposure duration does not match the 24-hour criterion. Therefore, potential effects to the health of off-duty workers at the temporary construction camp would not be expected due to air quality during the Construction phase.

During the Operations phase, the maximum predicted 24-hour concentration of PM_{10} was greater than the BC AAQO only at the upper pullout area for snowmobiles (Table 21.5-3 and Figure 2 in Appendix 21-C). However, snowmobilers will only be at this location for a few minutes at a time while pulled over allowing trucks to pass, therefore the 24-hour PM_{10} BC AAQO is not applicable to this location as it applies to a 24-hour exposure. It is unlikely that effects to human health would occur due to transient, short-term exposure of snowmobilers (or other users) to elevated particulate levels at this location. All other 165 human health receptor locations modelled had CAC concentrations that were below BC AAQOs (see Figures 1 through 6 in Appendix 21-C) during the Construction and Operations phases. Since effects to human health from predicted air quality are unlikely, there are no residual effects on human health from air quality and air quality will not be considered further.

Characterization of Human Health Residual Effects due to Air Quality

The characterization of the residual effects is based on the timing, magnitude, geographic extent, duration, frequency, reversibility, and resiliency. The attributes for characterization of residual effects are summarized in Table 21.5-4.

Since PM_{10} (24-hour concentration) is predicted to be greater than the BC AAQO at one human receptor location in Construction phase (temporary construction camp located onsite) and one human receptor location during Operations phase (upper snowmobile pull out area) it is possible that there could be residual effects to human health. The magnitude is considered to be **negligible**; although the predicted concentrations are slightly higher than the BC AAQO, exposures are likely to be below the threshold for effects. It is likely that the predicted concentrations of PM_{10} during the Construction phase are overestimated for the nighttime period, which is when there is potential for exposure of off-duty workers. This is because the only emission sources at night are the generators and incinerator, thus concentrations at night will likely be lower than the BC AAQO. Residual effects to human health due to PM_{10} during the Operations phase are also unlikely since people would only be at the potential upper snowmobile pullout for a very short time (the guideline is based on a 24-hour exposure period).

The geographical extent is considered to be **local**, since the residual effect is confined to the LSA and occurs at only a few human receptor locations in close proximity to Project infrastructure. The duration of the effect is **short-term** for the Construction phase and **medium-term** for the Operations phase, since the potential for residual effects may occur throughout the phases. The frequency is **regular**, since it is possible that PM_{10} may be elevated on a regular basis in the areas closest to the Project. The residual effect is considered to be **reversible**, since the effect is likely to diminish in human receptors once exposure ends. Resilience is **neutral**, since some people are more sensitive to PM_{10} than others.

Table 21.5-4. Definitions of Specific Characterization Criteria for Human Health

Timing	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Resiliency
When will the effect begin?	*How severe will the effect be?*	*How far will the effect reach?*	*How long will the effect last?*	*How often will the effect occur?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population? Will it be able to adapt to or absorb the change?*
Construction Phase	**Negligible:** no detectable change from baseline conditions.	**Discrete:** perceptible effect is limited to area within metres from the source.	**Short term:** effect lasts less than 2 years (i.e., during the Construction Phase of the Project).	**One time:** effect is confined to one discrete event.	**Reversible:** effect can be reversed.	**High:** the receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.
Operations phases (Stages 1 and 2)	**Low:** differs from the average value for baseline conditions but remains within the range of natural variation and below a guideline or threshold value.	**Local:** perceptible effect is limited to a few kilometres from the sources.	**Medium term:** effect lasts from 2 to 30 years (i.e., during the Operations Phases of the Project).	**Sporadic:** effect occurs rarely and at sporadic intervals.	**Partially reversible:** effect can be partially reversed.	**Neutral:** the receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.
Closure phase	**Medium:** differs substantially from the average value for baseline conditions and approaches the limits of natural variation, but equal to or slightly above a guideline or threshold value.	**Regional:** effect occurs throughout the Regional Study Area beyond 5 km from the source.	**Long term:** effect lasts from 30 to 37 years (e.g., during the Closure Phase of the Project).	**Regular:** effect occurs on a regular basis.	**Irreversible:** effect cannot be reversed, is of permanent duration.	**Low:** the receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.
Post-Closure phase	**High:** differs substantially from baseline conditions and is significantly beyond a guideline or threshold value, resulting in a detectable change beyond the range of natural variation.	**Beyond regional:** effect extends beyond the Regional Study Area.	**Far future:** effect lasts more than 37 years (e.g., during the Post-closure Phase and beyond).	**Continuous:** effect occurs constantly.		

Likelihood of Human Health Residual Effects due to Air Quality

Likelihood refers to the probability of the predicted residual effect occurring and is determined according to the attributes identified in Table 21.5-5.

Table 21.5-5. Attributes of Likelihood of Effects

Probability Rating	Quantitative Threshold
High	> P80 (effect has > 80% chance of effect occurring)
Moderate	P40 - P80 (effect has 40 - 80% chance of effect occurring)
Low	< P40 (effect has < 40% chance of effect occurring)

The likelihood of residual effects on human health due to air quality is **moderate**. While PM_{10} is predicted to be greater than the guidelines, based on the air quality model, it is likely that the model is overestimating the concentration of PM_{10} and that exposure of human receptors is likely to be lower.

21.5.3.2 Residual Effects on Human Health due to Country Foods Quality

Residual Effects to Human Health from Changes in Country Foods Quality due to Changes in Soil or Vegetation Quality

Air quality modelling results demonstrate that fugitive dust deposition ("dusting") on soil and vegetation will be local in nature, predicted to occur predominantly in sections along the access road and north west of the Project Site (see Section 9.5.3).

Wildlife with smaller home ranges that live close to the Mine Access Road or Project Site may ingest dusted vegetation and soil and could have a higher intake of COPCs than during baseline (pre-Project). However, noise from the Project and increased human activity levels at the Project Site and along access roads will likely keep wildlife away from the areas predicted to have the most dust deposition. Berries and other edible vegetation near the Mine Access Road and Project Site may be affected by dust generated by road upgrades, maintenance, and use. However, access to the Project will be limited to authorized vehicles from the junction of Vavenby Mountain FSR with Birch Island-Lost Creek Road. Since access to the Mine Access Road and Project Site will be restricted, it is unlikely that residents from local communities will harvest country foods that reside or grow within these areas. In addition, Health Canada recommends that fresh fruits be washed before consumption (Health Canada 2009b), which will decrease the dust (and metal) concentration present on the surface of edible plants or berries.

Residual Effects to Human Health from Changes in Country Foods Quality due to Changes in Water Quality

The effects assessment for the surface water quality VC found that potential effects on surface water quality due to erosion and sedimentation and atmospheric dust deposition were mitigated and residual effects were not predicted (Section 13.5.1 and 13.5.2). However, the effects assessment for the surface water quality VC found that Project has the potential to change surface water quality by:

- releasing effluent potentially affected by metal leaching/acid rock drainage (ML/ARD; i.e. TMF discharge to T Creek in Closure and Post-Closure); and

- seepage loss from within the Project footprint.

Should Project-related emissions and effluent change metal concentrations in soil, vegetation, or water contained in effluent or seepage enter the food chain, there is the potential for metal bioaccumulation to occur in country foods. Residual effects from seepage are discussed in detail in Section 13.5.4.

Aquatic Country Foods (Fish)

The surface water quality effects assessment (Section 13.5.3) identified dissolved cadmium, total copper, total selenium, sulphate, and total zinc as COPCs for aquatic life (see Chapter 13, Section 13.5.3).

Thus, fish have the potential to take up COPCs from the aquatic environment and accumulate them in their tissues, and the fish can then be eaten by human consumers. Selenium was identified as a COPC for aquatic life at the P Creek, T Creek, HP (Harper Creek, downstream of the confluence with P Creek), HT (Harper Creek just downstream of the confluence with T Creek), and HB (Harper Creek upstream of Barrière Lake) modelling nodes. The maximum predicted concentration of selenium was 6.2 µg/L at the P Creek node, 6.0 µg/L at the HP node, 12.1 µg/L at the T Creek node, 5.9 µg/L at the HT node, and 3.2 µg/L at the HB node.

Since a site-specific selenium bioaccumulation model for fish could not be developed for the Project (see the Selenium Management Plan Section 24.12.5.2), the concentration of selenium in fish tissues cannot be predicted at this time. However, the Selenium Management Plan outlines a monitoring program that will be implemented to support the development of a site-specific selenium bioaccumulation model for fish, which would allow the prediction of fish tissue selenium concentrations. Due to the identification of selenium as a COPC at the P Creek, HP, T Creek, HT, and HB modelling nodes, there is the potential for residual effects to human health due to the consumption of fish. However, for a risk to human health to occur, it is likely that a substantial quantity of fish from the affected creeks would need to be consumed on a regular basis, which is unlikely due to the low frequency of harvesting fish from the upper Harper Creek watershed in particular.

Total copper, dissolved cadmium, dissolved sulphate, and total zinc were also identified as potential COPCs for aquatic life. The DWQG for sulphate is aesthetic and based on taste considerations, as sulphate only poses a laxative effect in some individuals when concentrations are above 500 mg/L (Health Canada 1996), thus sulphate will not be assessed for country foods.

In the country foods baseline report (Appendix 21-A), the human exposure ratios for copper, cadmium, and zinc due to fish consumption (Rainbow and Bull Trout) were calculated to be 0.000488, 0.0021, and 0.0023, respectively; an ER of ≤ 0.2 is considered to be an acceptable level of risk. Assuming that the bioaccumulation of these metals into fish tissue occurs directly in proportion to changes in water concentration, water concentrations would need to increase from baseline by two (for cadmium and zinc) or three (cadmium) orders of magnitude for there to be a health risk for humans consuming fish. The predicted increases in cadmium and copper concentrations in water are substantially less than that (Chapter 13 and Appendices 13-C and 13-D), so it is unlikely that human health would be affected by the change concentration of metals in fish tissue.

Terrestrial Country Foods (Wildlife)

The surface water quality effects assessment (Section 13.5.3) identified selenium as a COPC for wildlife (see Chapter 13, Section 13.5.3 and Appendix 13-D). In the country foods baseline report (Appendix 21-A), the human exposure ratio for selenium was calculated to be 0.00004 for the consumption of moose, 0.00000008 for the consumption of snowshoe hare, and 0.00001 for the consumption of grouse; an ER of less than or equal 0.2 is considered to be an acceptable level of risk. Thus, water selenium concentrations would need to increase from baseline levels by more than three orders of magnitude for moose, by almost seven orders of magnitude for snowshoe hare, and more than four orders of magnitude for grouse for there to be a potential health risk for humans consuming these terrestrial country foods.

The tissue selenium concentrations in the baseline country foods assessment were predicted using a food chain model (Appendix 21-A). The food chain model was based on inputs of baseline water, soil, and vegetation quality. The maximum baseline water selenium concentration used in the food chain model (as drinking water for wildlife) to predict wildlife tissue concentrations was 0.0007 mg/L, while the maximum predicted water selenium concentration in the Expected Case during the Closure or Post-Closure phases in Harper Creek is 0.0056 mg/L. The water concentration of selenium is predicted to increase by approximately an order of magnitude, which is below the increase required for there to be health risks associated with consuming terrestrial country foods (assuming a direct linear relationship between wildlife tissue residues and water concentrations of selenium). However, the primary route of exposure to selenium for terrestrial wildlife species is via the diet and ingestion of soil; increased water selenium concentrations may not be significant to terrestrial wildlife species.

No other COPCs were identified with the potential to affect the health of wildlife. However, for the purposes of assessing country foods quality, it was assumed the same three metals (i.e., copper, cadmium, and zinc) identified as COPCs for aquatic life could bioaccumulate in terrestrial country foods through ingestion of surface water. Maximum baseline water concentrations used in the food chain model to predict wildlife tissue concentrations were 0.299 mg/L for copper, 0.0002 mg/L for cadmium, and 0.181 mg/L for zinc. The maximum predicted water concentration for copper was 0.0057 mg/L, 0.00011 mg/L for cadmium, and 0.012 mg/L for zinc (Appendix 13-C); these concentrations are lower than used in the baseline food chain model.

The baseline water quality data used as inputs into the food chain model were collected from a number of sites that were not included in the water quality model (as they will not be affected by the Project), which explains why baseline maximum water concentrations of copper, cadmium, and zinc were higher than the predicted concentrations as the site locations do not match. However, the country foods model used the higher baseline water concentrations and found no risk to human health from the consumption of terrestrial country foods. Thus, it is likely that the lower water concentrations predicted by the water quality model would also pose no risk to human health due to the consumption of terrestrial country foods (i.e., risk due to the Project is the same as the risk during the baseline studies, pre-Project development).

Characterization of Human Health Residual Effects due to Country Foods Quality

Based on the preceding assessment, it is possible that Project-related COPCs may affect the quality of (aquatic) country foods, which could in turn have the potential to affect human health. Therefore, to be conservative, the consumption of country foods was carried forward as a residual effect of the human health VC.

The attributes for characterization of country foods residual effects are summarized in Table 21.5-4 and these defined attributes will be used to characterize country foods residual effects.

Air and water emissions from the Project will take place during all phases of the Project, thus the quality of country foods has the potential to be affected during all four Project phases. Potential changes in country foods due to changes in water quality are most likely to occur during the Closure and Post-closure phases, once discharge from the TMF begins to occur. Potential changes in country foods due to dust deposition (affecting soil and vegetation quality) are most likely to occur in the Construction and Operations phases in areas closest to the Project footprint, but would have a minimal effect on the quality of country foods.

The magnitude of residual effects to human health from consumption of country foods is **negligible**. Although changes in air or water quality could lead to changes in the quality of country foods, it is unlikely that this would translate into an effect on human health (i.e., concentrations are likely to be below threshold values for effects and effects to human health are likely to remain similar to baseline conditions).

Dusting of soil and vegetation (which could affect the quality of country foods) is predicted to occur in close proximity to the Project, so the geographic extent would be **local**. However, changes in water quality (which could change the quality of aquatic country foods such as fish) are **regional**. Based on the surface water quality model results (Appendix 13-C), residual effects are predicted at the edge of the LSA (i.e., at the HB modelling node in lower Harper Creek) due to changes in water quality (Section 13.5.3), which could also affect fish (Section 14.5.3.2). Based on further qualitative assessment, it is possible that water quality may change within the RSA at the outlet of North Barrière Lake and in the Barrière River, until dilution is sufficient to reduce concentrations of cadmium, copper, and selenium to below BC WQG or background conditions. Changes in water quality could affect the quality of aquatic country foods (fish) within a small portion of the RSA. In addition, fish or wildlife can move or migrate from affected areas to areas further away from the Project, and the people most likely affected by any change in the quality of country foods are likely from the region surrounding the Project. Therefore, the geographic extent of the residual effects to country foods is considered **regional**.

The descriptor for the duration of the residual effect is based on how long the potential effect may last in a human receptor and is not directly tied to the duration of the exposure. Potential human health effects may range from acute to chronic effects, which may be reversible or irreversible; therefore, the residual effect was considered to be **partially reversible** and the duration can be considered **long term**. The duration also takes into consideration the water quality model predictions (Chapter 13 and Appendix 13-C), which suggest that there could be long-term or far future residual effects to water quality throughout Harper Creek. The frequency of residual effect to human health due to change in the quality of country foods is expected to be **sporadic**, as changes in air and water quality only occur during specific periods, and people are likely to consume country foods collected with the LSA occasionally. There may be consumers of country foods with increased susceptibility to elevated COPC concentrations in food (e.g., toddlers or pregnant women); therefore, resiliency is considered to be **low**.

Likelihood of Human Health Residual Effects due to Country Foods Quality

Likelihood refers to the probability that the predicted residual effect to human health from the consumption of country foods will occur and is determined according to the attributes identified in Table 21.5-5.

The likelihood of residual effects to human health due to a change in county foods quality as a result of Project activities and infrastructure is **low,** since the overall potential for exposure of human receptors to country foods from the LSA is low. Although changes in the quality of country foods may occur, particularly for aquatic organisms such as fish in Harper Creek, it is unlikely that the concentration of metals in the tissue of the country foods will surpass thresholds for effects in human consumers or result in residual effects to human health that are noticeably different than baseline conditions (i.e., magnitude of the residual effect is negligible). In addition, there is limited potential for human receptor harvesters to collect country foods from the areas closest to the Project where any changes to the quality of country foods are likely to be highest (e.g., due to mitigation measures such as access control and "no hunting and fishing" policies), and there has been no recreational fishing reported on Harper Creek.

21.5.3.3 Residual Effects on Human Health due to Drinking Water Quality

Methodology for Assessing Residual Effects to Human Health due to Drinking Water Quality

To assess residual effects to human health from changes in drinking water quality due to Project-related activities, future surface water quality was modelled. The methodology and assumptions used in the water quality model and the results are described in Chapter 13 and Appendix 13-C. Water quality modelling provided quantitative estimates of predicted surface water quality at several modelling nodes located downstream of the Project. A screening process was used to select COPCs for human health due to predicted drinking water quality changes during each of the phases of the Project.

Consistent with the approach used in the characterization of baseline drinking water quality (Section 21.4.3.3), predicted surface water quality at the modelling nodes located within the RSA was compared to BC DWQGs (BC MOE 2013h). If there is no BC DWQG for a parameter, then the Canadian DWQGs (Health Canada 2012) were used instead.

Hazard quotients (HQs) were calculated on a monthly basis by dividing the predicted concentration of parameters (from the Expected Case) by the applicable health-based DWQG at each of the modelling nodes (Chapter 13, Section 13.5.3 and Appendix 13-D). If a metal was found to have a HQ less than 1.0 (relative to the guideline) for a particular modelling node it would not be considered further, since these parameters would not be expected to cause adverse health effects if surface water was to be used as drinking water at that location.

If a metal was found to have a HQ greater than 1.0 relative to the guideline limit at a particular receptor location, the metal would be retained for a second screening step. In the second step, the predicted water concentration was compared to the baseline water concentration. This step was done to ensure that residual effects are based on only those COPCs with concentrations that were predicted to have a measureable increase beyond baseline levels due to Project-related activities. This process eliminates COPCs with concentrations that were greater than guidelines during the baseline studies (which is not a Project-related effect) and are not predicted to have a further increase in concentration due to the Project. COPCs that were greater than DWQGs during baseline studies were considered for their potential effects to human health in the Baseline Conditions section of this chapter (Section 21.4.3.3).

If a predicted metal concentration was greater than both the guideline limit and baseline concentration, then it would be identified as a COPC and would be assessed for residual effects on human health.

Screening for COPCs based on surface water quality model results was completed in Chapter 13, Section 13.5.3, with detailed results shown in Appendix 13-D.

Assessment of Residual Effects to Human Health due to Drinking Water Quality

As seen in Chapter 13, Appendix 13-D, all predicted metal concentrations (except for selenium in the Closure phase) at the water quality modelling nodes were below the BC DWQGs, thus all the HQs were below 1.0. For water quality sites that were not modelled, the concentrations of metals were assumed to be the same as baseline concentrations (i.e., unchanged due to the Project, with no potential for residual effects due to the Project).

During the Closure phase, selenium was greater than the DWQG (10 µg/L) at the T Creek modelling node from September to April of Years 31 to 35 (maximum HQ of 1.21; selenium concentration of 12.1 µg/L). During the Post-Closure phase, selenium was greater than the DWQG (10 µg/L) at the T Creek modelling node generally from September to March from Years 36 to 39 (maximum HQ of 1.08; selenium concentration of 10.8 µg/L).

The residual effects to human health due to drinking water quality will only occur if the concentration of a parameter is high enough (i.e., beyond a toxicity threshold), a receptor is present, and there is an exposure pathway (Section 21.1 and 21.5.1.3). For T Creek, it is unlikely that an exposure pathway exists that will lead to exposure of human consumers on a continuous, long-term (chronic) basis. There are no surface water licences on T Creek and no permanent residences in the vicinity. In the event that temporary land users (e.g., for hunting, trapping, fishing, camping, or other recreation) were to use this creek for drinking water purposes during short-term trips through the area, health effects from intake of selenium are unlikely. This is because the DWQG are expected to be protective of daily or chronic exposure rather than a short-term, one-time exposure. Therefore, the concentration of selenium predicted in the water downstream of the TMF would not be expected to have residual effects to human health and will not be considered further.

While groundwater flow (quantity) was modelled in this Application/EIS (Chapter 11, Section 11.5), groundwater quality was not. However, baseline data indicated that groundwater quality is below

DWQGs (Section 21.4.3.3) and upon implementation of the Groundwater Management Plan (Section 24.8) and mitigation measures (Section 21.5.2) there will likely be no Project-related changes to groundwater quality at human receptor locations where groundwater is accessible (e.g., groundwater well locations).

Characterization of Human Health Residual Effects due to Drinking Water Quality

Since selenium is predicted to be greater than the DWQGs in T Creek, it is possible that there could be residual effects to human health. The magnitude is **negligible**; although the predicted concentrations are slightly higher than the DWQG, there are no known human receptors that would consume water from T Creek on a regular basis. The geographic extent is **local**, since the potential for residual effects is predicted to occur only within T Creek, within the LSA. Elevated selenium concentrations are predicted to occur during the Closure and Post-Closure phases, with the duration being **medium-term** (effect lasts between 2 and 30 years). The potential for residual effects occurs **regularly** during the Closure and (early) Post-Closure phases, but is considered to be **reversible** once exposure is stopped. Resilience is **neutral**, since the predicted concentration of selenium in T Creek is not likely to be high enough to cause effects in humans who might consume this water on a transient, short-term basis while passing through the area.

Likelihood of Human Health Residual Effects due to Drinking Water Quality

The likelihood of residual effects to human health due to drinking water quality (i.e., elevated selenium concentrations) is **low**. This is because selenium is predicted to be greater than DWQGs only in T Creek, which is not used as regular drinking water sources (i.e., no surface water licenses for T Creek). Effects to human health due to short-term use of T Creek as a drinking water source is unlikely, since the predicted concentrations are not substantially greater than DWQG and DWQGs are intended to be protective of long-term exposure through drinking water. Groundwater quality is not expected to change significantly at the human receptor locations where domestic wells are used for drinking water (i.e., to the north of the Project). Therefore, effects to human health due to changes in drinking water quality are unlikely.

21.5.3.4 Residual Effects on Human Health due to Noise

The noise chapter (Chapter 10, Section 10.5.2) provides details of the modelling undertaken to assess the environmental effects of noise associated with the proposed Project during the Construction phase (year 1 and 2) and Operations 1 phase (year 13). Note that receptors with insignificant noise levels (i.e., less than 30 dBA) are not presented. A full summary of results can be found in Appendix 21-B.

The noise model receptor locations are described in detail in Chapter 10, Section 10.5.2.3 Noise receptors were defined as any point off-site occupied by persons where extraneous noise may be received. Evaluation of the Project includes 68 human receptors within the noise RSA (Chapter 10, Figure 10.3-1). The proposed pullout areas for snowmobiles will be created during the Construction phase as locations where people can pull over to allow haul trucks to pass. Human receptors may also stay overnight at the snowmobile cabins occasionally. Receptors identified as town, surface water licence (BC MFLNRO, BC HA), groundwater licence (BC HA), and well are assumed to be associated with residential dwellings.

A temporary modular construction camp will be positioned at the Project Site to house the construction workforce peaking at 600 construction personnel, and will be removed at the end of the Construction phase. In the assessment, it is assumed that the 70-hour work week occurs during the daytime and there are no construction activities during the nighttime. Therefore, sleep disturbance will not occur during the Construction phase at the construction camp. During the Operations phase, personnel will reside off site in local communities such as Vavenby, Clearwater, and surrounding areas. While present at work, workers are covered by WorkSafe BC (2014) regulations and the Health, Safety and Reclamation Code for Mines in BC (BC MEMPR 2008), and were therefore not assessed while on duty.

Assessment Methodology and Metrics used to Assess Noise Effects on Human Health

In this assessment, three types of noise sources are identified, namely noise from Project construction or operations, noise from increase in traffic volume, and noise from blasting. Different approaches are taken to assess noise from these three sources and more information is provided in Chapter 10, Section 10.5.4. Project-specific criteria have been chosen to rate potential effects for off-site receptors as shown in Table 21.2-4 and discussed in Section 21.5.1.4.

Sleep Disturbance

A good night's sleep requires indoor nighttime equivalent sound levels (L_n, L_{eq}, 22:00 to 07:00 hours) of continuous background noise below 30 dBA and individual noise events exceeding 45 dB (L_{eq}) should not occur more than 10 to 15 times per night (WHO 1999). Sensitivity to noise disturbance varies considerably between individuals, and this guideline is taken to apply to the whole population; therefore, the vast majority of the population would not suffer sleep disturbance above these levels. Vehicle pass-by can contribute to sleep disturbance and therefore was included as a source in the assessment. Thus the assessment of sleep disturbance included both Project noise and traffic noise.

For receptor locations where people will be sleeping indoors, the US EPA (1974) suggests assuming an outdoor-to-indoor noise level reduction of 15 dBA if windows are slightly open and 27 dBA if windows are closed. The actual sound reduction depends on construction materials, geometry, and other factors of the room and building. Given that the Project is located in a low-temperature climate, building shells will be built more airtight and actual noise reduction levels are expected to be higher. Since it is expected that people will be sleeping indoors at cabins and residences in the towns, it is assumed that noise reduction of 15 dBA applies in these areas. The indoor sound attenuation would not apply to people sleeping in tents in campgrounds that are located near the Project.

Interference with Speech Communication

Normal speech has a sound pressure level of approximately 55 to 58 dBA (Levitt and Webster 1991), and indoor noise with sound levels of 40 dBA or more interferes with speech comprehension (US EPA 1974). Outdoors, background noise levels should be kept below 55 dBA (L_d) for continuous noise (US EPA 1974). Section 10.5.2.2 describes each modelling scenario considered. Speech interference was assessed during the day for the Construction phase (construction of the road, use of the road, and all other activities at the mine) and the Operation phase (traffic noise and all other activities at the mine).

Noise and Vibration from Blasting

Generally, ground-borne vibration and air-blast overpressure levels that result in human discomfort are set by regulatory authorities at levels less than those likely to cause damage to structures, architectural elements and services. Detailed information on the assessment of vibration and blasting is provided in Chapter 10, Section 10.5.4.1.

As is apparent in the various international standards and guidelines applicable to blasting, the effect of blast events on people is subjective, as one person may tolerate high levels that would be unacceptable to someone else. Human comfort limits for air-blast are linked to the annoyance produced. Several factors contribute to annoyance such as loudness, duration and number of events plus the time of day and the nature of the disturbance.

The US EPA (1974) found little or no public annoyance is expected to result from any number of daytime sonic booms per day if the measured or predicted peak level is less than (125 – 10 log N) dBL, with N being the number of booms per day. In this case, HCMC plans to have 159 blasts per year during the construction phase and 331 blasts per year during the Operations phase with a maximum of one blast per day; therefore, the peak level threshold is 125 dBL. WHO (1999) provides guideline levels for noise-induced hearing impairment with peak value of 140 dB for adults, and 120 dB for children. The assessment for human health is based on 120 dB for blasting noise as a conservative approach.

High Annoyance

Health Canada (2010e) suggested that the “Percent Highly Annoyed” or “%HA” metric, which is calculated using the adjusted L_{dn} (or Rating Level) pre- and post-Project, is “an appropriate indicator of noise-induced human health effects for project operational noise and for long-term construction noise exposure”. Other than traffic noise, Project-related noise is not expected to extend to any of the human health receptor locations, thus the determination of %HA was conducted for traffic noise alone.

In the document, Using a Change in Percent Highly Annoyed with Noise as a Potential Health Effect Measure for Project under the Canadian Environmental Assessment Act (Michaud, Bly, and Keith 2008), it was stated that the US Federal Transit Administration's (FTA) document Transit Noise and Vibration Impact Assessment (Harris Miller Miller & Hanson Inc. 2006) developed criteria that assess the significance of noise increase from traffic projects. The assessment criteria were developed based on noise impact from transit noise sources and are more applicable to address the increase in noise due to increase in traffic. The referenced noise impact criteria provided by the FTA are based on the relationship between the percentage of "highly annoyed" people and the noise exposure levels of their residential environment resulting from transportation noise. This relationship (shown in Chapter 10, Figure 10.5-7), has been used to provide an indication of the likelihood of noise impacts from the road traffic noise generated by the Project.

The FTA's suggested noise impact criteria are dependent on the existing noise exposure levels at the assessment locations. Below the lower curve (shown in Chapter 10, Figure 10.5-7), a project is considered to have “no impact” on noise since on average, the in-traffic noise associated with the project will result in an insignificant increase in the number of people highly annoyed by the new noise. Project noise above the upper curve is considered to cause a "severe impact" since a significant percentage of people would be highly annoyed by the new noise. The criterion for a severe impact (upper curve) is based on an increase of 6.5% in %HA for baseline values between 43 to 77 dBA (Health Canada 2010e). Between the two curves, the proposed Project is considered to have "moderate impact" where the change in noise is noticeable to most people, but it may not be sufficient to cause strong, adverse reaction from the community.

In the context of the Project, where existing road traffic noise levels are in the range of 50 to 55 dBA (see Section 10.5.4.1), based on the FTA criterion (Harris Miller Miller & Hanson Inc. 2006) an increase of:

- less than 3 to 5 dBA would be considered "no impact";
- 5 to 8 dBA would be considered "moderate impact"**;** and
- greater than 8 dBA would be considered "severe impact".

Assessment of Residual Effects to Human Health due to Noise

Construction Phase

Interference with Speech Communication

Calculated noise levels from the Construction phase noise model for construction of the access road (CON-01) at various receptor locations are presented in Table 21.5-6. Predicted external daytime noise levels (L_d) are expected to be lower than the recommended criteria of 55 dBA (US EPA 1974) in order to avoid interference with speech communication. The highest noise level predicted during the construction of the access road is 49 dBA at the surface water licence location (C124889) northeast of the Project Site in close vicinity to the access road.

Table 21.5-6. Predicted Noise Levels during the Construction Phase – Construction of Access Road

ID	Receptor	L_d [a] (dBA)	L_d [b] Criteria (dBA)
T02	Surface Water Licence (BC MFLNRO) - C124889	49	55
T04	Surface Water Licence (BC MFLNRO) - C130960	38	
T05	Surface Water Licence (BC MFLNRO) - C130960	38	
T06	Surface Water Licence (BC MFLNRO) - C036251, C036252, C036257, C036258, C036469, and C056116	31	
T11	Surface Water Licence (BC MFLNRO) - C036251, C036252, C036257, C036258, C036469, and C056117	31	

Notes:
[a] Construction activities occur during the daytime only.
[b] Daytime noise level for assessing speech interference.
Human receptor locations with predicted noise levels lower than 30 dBA are not shown in the table.

Calculated noise levels from the construction of mine infrastructure during the Construction phase (CON-02) at various human receptor locations are presented in Table 21.5-7. Predicted external daytime noise levels (L_d) at most receptor locations are expected to be lower than the recommended criteria of 55 dBA (US EPA 1974) in order to avoid interference with speech communication.

Table 21.5-7. Predicted Noise Levels during the Construction Phase – Construction of Mine Infrastructure

ID	Receptor	L_d [a] (dBA)	L_d [b] Criteria (dBA)
M01	Potential Pullout Area for Snowmobile – Upper Pullout area	**56**	55
T01	Potential Pullout Area for Snowmobile – Lower Pullout Area	52	
T02	Surface Water Licence (BC MFLNRO) - C124889	47	
T04	Surface Water Licence (BC MFLNRO) - C130960	38	
T05	Surface Water Licence (BC MFLNRO) - C130960	38	
T06	Surface Water Licence (BC MFLNRO) - C036251, C036252, C036257, C036258, C036469, and C056116	31	
T11	Surface Water Licence (BC MFLNRO) - C036251, C036252, C036257, C036258, C036469, and C056116	31	

Notes:
[a] *Construction activities occur during the daytime only.*
[b] *Daytime noise level for assessing speech interference.*
Shaded value indicates exceedance of criteria.
Human receptor locations with predicted noise levels lower than 30 dBA are not shown in the table.

The only receptor location where the predicted noise levels are greater than the speech interference criterion (US EPA 1974) is at the potential upper pullout area for snowmobiles outside the mining area (M01). The predicted noise level of 55.6 dBA at this location is 0.6 dBA above the criterion.

High Annoyance

Calculated noise levels from the noise model of Construction phase road traffic at various human receptor locations are presented in Table 21.5-8. Predicted road traffic noise levels (L_d) are not expected to increase by more than 2 dBA at any of the human receptor locations and are considered by the FTA to have "low impact" (see Figure 10.5-7; Harris Miller Miller & Hanson Inc. 2006).

Table 21.5-8. Predicted Noise Levels during Construction Phase – Road Traffic

Road	Nearest Receptor (m)	Calculated Existing Road Traffic Noise Level $L_{Aeq, 1\text{-}hr}$ [a] (dBA)	Predicted Project Construction Road Traffic $L_{Aeq, 1\text{-}hr}$ (dBA)	Predicted Total Road Traffic Noise Level $L_{Aeq, 1\text{-}hr}$ (dBA)	Increase (dBA)	Impact[b]
McCorvie	13	54.0	51.2	55.8	1.8	Low
Vavenby	13	57.0	52.4	58.3	1.3	Low
Capostinsky	20	52.7	48.0	53.9	1.2	Low

Notes:
[a] *Based on worst-case afternoon peak traffic volumes and maximum existing logging truck traffic of 50 vehicles per day (two-way).*
[b] *As per FTA's suggested noise impact criteria.*

Operations Phase

Sleep Disturbance and Interference with Speech Communication

Modelled noise levels from the mining activities during the Operations phase with respect to human receptors are presented in Table 21.5-9. Predicted noise levels from mining operations in the township of Vavenby are less than 30 dBA at all identified receptor locations, resulting in no increase in %HA, and hence have not been provided in the results tables.

Table 21.5-9. Predicted Noise Levels during the Operations Phase – Mining

ID	Receptor	Calculated Noise Level		Limiting Criteria	
		L_d (dBA)	L_n (dBA)	L_d [a] (dBA)	L_n [b] (dBA)
M01	Potential Pullout Area for Snowmobile – Upper Pullout Area [c]	**59**	n/a	55	45
T01	Potential Pullout Area for Snowmobile – Lower Pullout Area [c]	**56**	n/a		
T02	Surface Water Licence (BC MFLNRO) - C124889	51	**49**		
T04	Surface Water Licence (BC MFLNRO) - C130960	41	40		
T05	Surface Water Licence (BC MFLNRO) - C130960	42	40		
T06	Surface Water Licence (BC MFLNRO) - C036251, C036252, C036257, C036258, C036469, and C056116	35	34		
T07	Surface Water Licence (BC MFLNRO) - C102945	30	29		
T11	Surface Water Licence (BC MFLNRO) - C036251, C036252, C036257, C036258, C036469, and C056116	35	34		
T12	Town - Vavenby	30	29		

Notes:
[a] *Daytime noise level for assessing speech interference.*
[b] *Nighttime noise level for assessing sleep disturbance inside the Project Site.*
[c] *People are not expected to be sleeping overnight at the pullout areas; therefore, sleep disturbance is not assessed.*
Shaded values indicate exceedance of criteria.
n/a = not applicable because people do not sleep at these locations.
Human receptor locations with predicted noise levels lower than 30 dBA are not shown in the table.

Predicted external daytime noise levels (L_d) are expected to be lower than the recommended criteria of 55 dBA (US EPA 1974) at all receptor locations, with the exception of the upper (M01) and lower (T01) snowmobile pullout areas. Considering the use of these locations, such exceedances would be considered as negligible impact since people are only expected to be present at the location for a matter of minutes on an idling snowmobile.

Predicted nighttime noise levels (L_n) were greater than the sleep disturbance criteria at human receptor location T02, a surface water licence location (C124889) close to the town of Vavenby. It is assumed that each surface water licence location is associated with a house or other place where people may reside in close proximity. The source of noise that affected this location would be traffic noise, given that this receptor location is 5,835 m from the Project Site and only 25 m from the access road. Since this location is close to the access road, it is assumed that the existing noise level, from existing traffic, would already be high. As discussed in Chapter 10, Section 10.5.4.1, an increase in traffic noise will be assessed using FTA's method, and is presented below.

High Annoyance

Calculated noise levels from Operations phase road traffic with respect to human receptors are presented in Table 21.5-10. Predicted external road traffic noise levels (L_d) are not expected to increase by more than 2 dBA at Vavenby Road and Capostinsky Road. At McCorvie Road, an increase of 2.6 dBA is predicted; however, this increase relative to background conditions would be considered "low impact" (see Figure 10.5-7) since an increase of 3 dB would be considered just perceptible. The road distance to the nearest receptor captures all of the receptors by the road (i.e., including human health receptor T02).

Table 21.5-10. Predicted Noise Levels during the Operations Phase – Road Traffic

Road	Nearest Receptor (m)	Calculated Existing Road Traffic Noise Level L_{Aeq}, 1-hr [a] (dBA)	Predicted Project Construction Road Traffic L_{Aeq}, 1-hr (dBA)	Predicted Total Road Traffic Noise Level L_{Aeq}, 1-hr (dBA)	Increase (dB)	Impact[b]
McCorvie	13	54.0	53.1	56.6	2.6	Low
Vavenby	13	57.0	54.1	58.8	1.8	Low
Capostinsky	20	52.7	49.4	54.3	1.6	Low

Notes:
[a] *Based on worst case PM peak traffic volumes and maximum existing logging truck traffic of 50 vehicles per day (two-way).*
[b] *As per FTA's suggested noise impact criteria.*

Noise and Vibration from Blasting

HCMC indicated that the maximum instantaneous charge will be restricted to two holes and the delay time between charges will be at least 10 milliseconds; therefore, the maximum instantaneous charge considered in this assessment was based on two holes (826 kg per hole) with a total of 1,652 kg of explosive emulsion (see bold values in Table 21.5-11). The blasting assessment determines the distance (in meters) at which the guideline level for noise-induced hearing impairment (L_{peak} of 120 dB) for sensitive receptors (i.e., children) is surpassed. As shown in Table 21.5-11, a distance of more than 1,113 m is required to for air-blast overpressure to be below 120 dB (Standards Australia 2006). The extent of the 120 dB noise level from the blasting source is presented in Figure 10.5-6, and only the workers camp at the Mine Site falls within that area. Blasting will only occur during the day and noise levels in the workplace are regulated by WorkSafe BC, which has an employee exposure threshold of 140 dBC peak sound level during work hours (WorkSafe BC 2014).

Characterization of Human Health Residual Effects due to Noise

The attributes for characterization of noise residual effects are summarized in Table 21.5-4 and these defined attributes will be used to characterize noise residual effect.

Table 21.5-11. Predicted Noise Levels for Blasting

Number of Holes per Charge	Explosive Amount per Charge (kg)	Distance Required for < 120 dB (m)
1	826	884
2	**1,652**	**1,113**
3	2,478	1,274
4	3,304	1,402
5	4,130	1,511
6	4,956	1,605
7	5,782	1,690
8	6,608	1,767
9	7,434	1,838
10	8,260	1,903
11	9,086	1,965

Construction Phase

During the construction of Project infrastructure (Scenario CON-02), predicted external daytime noise levels (L_d) are expected to be below the recommended criteria of 55 dBA in order to avoid interference with speech communication with the exception of the potential upper pullout area for snowmobiles outside the mining area (M01; Table 21.5-7). At this pullout area, people are likely to stay for only a few minutes with a helmet on, which may include protection over the ears. Moreover, the noise level from snowmobiles, regulated to be less than 73 dBA at 50 feet away while travelling at 15 mph (International Snowmobile Manufacturers Association 2014), is likely to be higher than the noise from the trucks passing by. For these reasons, the magnitude of the predicted increase in noise levels predicted at this pullout area is considered **negligible**.

For road traffic, compared to the current noise level, the total road traffic noise level is predicted to increase less than 2 dBA compared to the existing road traffic noise. Based on the FTA noise criteria presented in Figure 10.5-7 of Chapter 10, an increase of less than 3 to 5 dBA is considered to have "low impact" on the increase in number of people highly annoyed. For blasting noise, none of the human health receptor locations are affected by an instantaneous noise level of more than 120 dB (Figure 10.5-6 of Chapter 10). Since none of the traffic noise and blasting noise criteria are exceeded for CON-01 and the exceedance for CON-02 is considered negligible, the magnitude is **negligible**.

The predicted Project noise is mainly limited to within 50 m from the road for traffic noise, and a few kilometres from the mines for CON-01 and CON-02. For blasting, the area affected for human sensitivity to impulse blasting noise is limited to 1.1 km from the blasting. Since the effect of construction activities (CON-01 and CON-02), traffic and blasting are limited to less than 5 km from the sources, the geographic extent is **local**.

During the two-year Construction phase, the frequency of increases in noise levels and traffic for transporting construction material is **regular** (CON-01 and CON-02), as construction activities are expected to occur 70-hours a week. Blasting is planned to take place once a day and 159 times a year which is considered to be **sporadic** in frequency. The overall frequency for the Construction phase is considered to be **regular**, with the majority of the noise sources occurring on a regular basis.

Increased noise levels will occur throughout the entire two year Construction phase (construction activities, traffic, and blasting) and is considered to be of **short-term** duration. The noise effect is considered **reversible** as the effect will disappear once the sources stop after construction activities end. The baseline noise level is 32 dBA at a location away from traffic, which is within the range expected for baseline rural noise levels. However, some areas that are affected by anthropogenic activities were found to have a baseline noise level of 56 dBA. Since the baseline condition in the area is affected by some anthropogenic activities, the environment is considered to have a **neutral** resilience to an increase in noise.

Operations Phase

During the Operations phase, noise levels from mining activities are not predicted to be greater than the criteria level for speech interference of 55 dBA, with the exception of the potential upper and lower pullout areas for snowmobiles (Table 21.5-9); however, considering the expected short-term use of these locations, the magnitude of the potential for effects to human health would be considered **negligible** as people are expected to be present at these locations for a matter of minutes on a (noisy) running snowmobile.

Predicted nighttime noise levels are greater than the sleep disturbance criteria at human receptor location T02, a surface water licence location (C124889) close to the town of Vavenby and close to Vavenby Road. Since this location is much closer to traffic (25 m) than to the mine (5,835 m), this location is characterized using the FTA guideline for traffic noise and the noise level at human health receptor location T02 is captured in the assessment of traffic on Vavenby Road. The predicted total road traffic noise levels at the three road locations indicated an increase of up to 2.6 dBA (Table 21.5-10) from the existing road traffic noise level. From the FTA's suggestion shown on Figure 10.5-7 in Chapter 10, it can be seen that an existing noise exposure level of 54 dBA, an increase of less than 3 dBA is considered to be "low impact". Furthermore, an increase of 3 dBA would be considered barely perceptible. With a few predicted noise levels from mining operation above noise criteria, and "low impact" from traffic noise, the overall magnitude of noise during the Operations phase is considered **negligible**.

The traffic noise is mainly limited to those receptors directly facing the road up to a few kilometres for the mining operation. For blasting, the area affected for human sensitivity to impulse blasting noise is limited to 1.1 km from the blasting; since elevated noise levels are predicted to extend less than 5 km due to mining operations, traffic, and blasting (i.e., remains within the LSA), the geographic extent is considered **local**.

During the Operations phase, the frequency of increase in noise level is **continuous** as noise from mining operations and road traffic for hauling material is expected whenever the equipment is operating, and mining operations are expected 24-hours a day and 365 days a year. Blasting is expected to be 331 blasts a year with a maximum of one blast a day, considered to be a **regular** frequency. The overall effect due to noise during the Operations phase is expected to last throughout the 23 years of active mining and is considered **medium** term.

The noise effect is considered **reversible**, as the effect will diminish once the sources cease operation. Since the baseline noise indicates that some areas are affected by anthropogenic activities, the receiving environment is considered to have a **neutral** resilience to increases in noise.

Likelihood of Human Health Residual Effects due to Noise

Likelihood refers to the probability of the predicted noise residual effect occurring and is determined according to the attributes identified in Table 21.5-5.

It is expected that noise is generated when equipment and vehicles are operating, or while mining operations are taking place. However, since human receptors are not continuously in the areas closest to the Project where noise levels are predicted to be highest, it is unlikely that residual effects to human health will occur. Noise levels are predicted to be marginally greater than some criteria at only a few human receptor locations, some of which are transiently used (e.g., snowmobile pullouts). The probability that an increase in noise levels will affect human health during the Project Construction and Operations phases is **low**.

21.5.3.5 Summary of Residual Effects on Human Health

The residual effect on human health due to changes in air quality (Section 21.5.3.1), country foods quality (Section 21.5.3.2), drinking water quality (Section 21.5.3.3), and noise (Section 21.5.3.4) was characterized in the previous sections and summarized in Table 21.5-12.

Table 21.5-12. Summary of Residual Effects on Human Health

Valued Component	Project Phase (timing of effect)	Cause-Effect [a]	Mitigation Measure(s)	Residual Effect
Human health due to changes in air quality	Construction and Operations	Project-related air emissions (PM_{10}) are greater than BC AAQOs at a human receptor location close to the Project and could affect human health	Air Quality Management Plan, including mitigation measures to decrease air emissions	Decrease in air quality that could affect human health
Human health due to changes in country foods quality	All phases	Project air and water emissions may decrease the quality of country foods	No hunting, fishing, or berry collecting at the Project Site; various management plans to minimize risk to environmental quality (e.g., air, water, soil, and vegetation quality) or VCs that are used as country foods (e.g., fish or wildlife)	Decrease in country foods quality that could affect human health in consumers of country foods

(continued)

Table 21.5-12. Summary of Residual Effects on Human Health (completed)

Valued Component	Project Phase (timing of effect)	Cause-Effect [a]	Mitigation Measure(s)	Residual Effect
Human health due to changes in drinking water quality	Closure and Post-Closure	Predicted increases in the concentration of selenium in surface water in T Creek are greater than the DWQG, which could affect human health if people were to routinely use T Creek as a long-term drinking water source	Various management plans to minimize the changes in water quality (e.g., Fish and Aquatic Effects Monitoring and Management Plan; Groundwater Monitoring and Management Plan; Mine Waste and ML/ARD Management Plan; Sediment and Erosion Control Plan)	Decrease in drinking water quality that could affect human health through consumption of water
Human health due to changes in noise levels	Construction and Operations Phases	Project construction and operation noise sources are predicted to increase noise levels at off-site human receptors close to the Project footprint	Noise Management Plan, including mitigation measures such as low noise emitting equipment will be preferentially selected, adequate maintenance, reduce vehicle speed, avoid idling, and optimize construction design and site layout	Increase in noise levels that could affect human health

[a] *"Cause-effect" refers to the relationship between the Project Component/physical activity that is causing the change or effect in the condition of the VC, and the actual change or effect that results.*

21.5.4 Significance of Residual Effects

The significance determination follows a two-step process; first the severity of residual effects is ranked according to a minor, moderate, and major scale (see Chapter 8, Table 8.6-1). The scale of the residual effect is determined by the magnitude of the residual effect and the nature of the sources: residual effect where low and medium magnitude is considered minor in scale; residual effect with high magnitude but mitigatable sources is considered moderate; and residual effect with high magnitude but difficult to mitigate or unmitigatable sources is considered major. The significance of the residual effect is determined using the ratings below:

- **Not significant (minor, moderate)**: Residual effects have low or medium magnitude; local to regional geographic extent; short- or medium-term duration; could occur at any frequency; are reversible or partially reversible in either the short or long-term, and with minor or moderate scale. The effect is either indistinguishable from background conditions or distinguishable at the individual level.
- **Significant (major):** Residual effects have high magnitude; regional or beyond regional geographic extent; duration is long-term or far future; and occur at all frequencies. Residual effect is consequential and is irreversible with major scale.

21.5.4.1 Human Health due to Changes in Air Quality

Since the residual effect to human health due to changes in air quality is of negligible magnitude, the geographic extent is local, the duration is short-term (Construction phase) or medium-term (Operations phase), the frequency is regular, the residual effect is reversible, and resilience is neutral, the residual effect is **not significant (minor)** during the Construction and Operations phases. Potential effects would be expected to be even lower during Closure and Post-Closure phases when Project-related activities and emissions are lower, so residual effects would not be predicted during those phases.

21.5.4.2 Human Health due to Changes in Country Foods Quality

Since the residual effect to human health due to changes in country foods quality is of low magnitude, the geographic extent is regional, the duration is long-term, the frequency is sporadic, the residual effect is partially-reversible, and the resilience is low, the residual effect for all Project phases is **not significant (minor)**.

21.5.4.3 Human Health due to Changes in Drinking Water Quality

Since the residual effect to human health due to changes in drinking water quality is of negligible magnitude, the geographic extent is local, the duration is medium-term (Closure and Post-Closure phases), the frequency is regular, the residual effect is reversible, and resilience is neutral, the residual effect is **not significant (minor)** during the Closure and Post-Closure phases. No residual effects to human health due to drinking water quality are predicted during the Construction and Operations phases, based on the outputs of the water quality model (Appendix 13-C and 13-D).

21.5.4.4 Human Health due to Changes in Noise Levels

During the Construction phase, the residual effects of the Project on increased noise levels are negligible in magnitude, local geographic extent, of regular frequency, and of short-term duration.

During the Operations phase the magnitude is negligible, geographic extent is local, frequency is regular, and duration is medium term.

During both phases, the residual effects on human health due to noise are considered reversible with neutral resiliency. The residual effects of the Project on noise levels during both the Construction and Operations phases are considered minor and **not significant (minor)**.

21.5.5 Confidence and Uncertainty in Determination of Significance

Confidence, which can also be understood as the level of uncertainty associated with the assessment, is a measure of how well residual effects are understood and the confidence associated with the baseline data, modeling techniques used, assumptions made, effectiveness of mitigation, and resulting predictions. In predictive assessment involving modelling, the uncertainty associated with the assessment is closely related to model limitations.

21.5.5.1 Human Health due to Changes in Air Quality

Uncertainty exists in every prediction of future change; however, the approach used to assess the effects on air quality was developed to incorporate quantitative data from baseline reports, where available, and air quality modelling, therefore providing a robust, transparent, and defensible approach to the effects assessment. The methodology used to calculate fugitive dust emissions was taken from provincial and federal guidelines and scientific papers. There are, however, uncertainties associated with the emission factors. The confidence in the magnitude of the residual air quality effects assessment is, therefore, **moderate** for TSP, PM_{10}, and $PM_{2.5}$.

21.5.5.2 Human Health due to Changes in Country Foods Quality

The country foods residual effects assessment was predominantly qualitative, with some semi-quantitative assessment based on outputs from the air quality and water quality models, thus the confidence in the determination of significance is **moderate**.

21.5.5.3 Human Health due to Changes in Drinking Water Quality

The confidence in the significance prediction was rated as **moderate** for the residual effect of the Project on water quality, based on the Water Quality Modelling Report prepared by Knight Piésold Ltd. (Appendix 13-C; Section 13.5.5; KP 2014).

21.5.5.4 Noise

For sound calculated using the ISO 9613 standard, the indicated accuracy is ± 3 dBA at source to receiver distances of up to 1,000 m and unknown at distances above 1,000 m. The noise modelling software is limited to calculate all sources within 10 km of a receiver point, as items at distances greater than 10 km would have no influence on the calculation.

The estimated sound power levels for mobile equipment are generally based on new and well-maintained equipment. Older pieces of mobile equipment would likely produce higher noise emissions. For individually modelled noise sources (fixed and mobile equipment and roads), the estimated accuracy of the sound power levels is ± 5 dBA.

Confidence level was determined using attributes outlined in Table 8.6-4. Uncertainty is expected with any predictive study although modelling is useful in determining effects. There is a fairly good understanding established for the cause-effect relationship of noise, but human response to it is highly subjective. For the above reasons, the confidence level for noise residual effect is considered **moderate**.

21.5.6 Summary of the Assessment of Residual Effects for Human Health

Residual effects to human health due to changes in air quality, country foods quality, drinking water quality, and noise are summarized in Table 21.5-13, including the associated characterization criteria (Table 21.5-4), significance, likelihood, and confidence in the determination.

Table 21.5-13. Summary of Key Effects, Mitigation, Residual Effects Characterization Criteria, Likelihood, Significance, and Confidence

Key Effect	Mitigation Measures	Summary of Residual Effects Characterization Criteria *(magnitude, geographic extent, duration, frequency, reversibility, resiliency)*	Likelihood *(High, Moderate, Low)*	Significance of Adverse Residual Effects		Confidence *(High, Moderate, Low)*
				Scale *(minor, moderate, major)*	Rating *(not significant; significant)*	
Decrease in air quality (PM_{10}) that could affect human health during Construction and Operations phases	Air Quality Management Plan, including mitigation measures to decrease air emissions	Negligible magnitude, local geographic extent, short-term (Construction phase) or medium-term (Operations phase) duration, regular frequency, reversible, and neutral resiliency	Moderate	Minor	Not significant	Moderate
Decrease in quality of country foods that could affect human health in consumers of country foods during all Project phases	No hunting, fishing, or berry collecting at the Project Site; various management plans to minimize risk to environmental quality (e.g., air, water, soil, and vegetation quality) or VCs that are used as country foods (e.g., fish or wildlife)	Negligible magnitude, regional geographic extent, long-term duration, sporadic frequency, partially-reversible, and low resiliency	Low	Minor	Not significant	Moderate
Decrease in drinking water quality that could affect human health through consumption of surface water during Closure and Post-Closure phases	Various management plans to minimize the changes in water quality (e.g., Fish and Aquatic Effects Monitoring and Management Plan; Groundwater Monitoring and Management Plan; Mine Waste and ML/ARD Management Plan; Sediment and Erosion Control Plan)	Negligible magnitude, local geographic extent, medium-term duration, regular frequency, reversible, and neutral resiliency	Low	Minor	Not significant	Moderate
Increase in noise levels that could affect human health during Construction or Operations phase	Noise Management Plan; Consider noise in equipment selection, adequate maintenance, reducing vehicle speed, and avoid idling, and optimize construction design and site layout	Negligible magnitude, local geographic extent, short-term (Construction phase) or medium-term (Operations phase) duration, regular frequency, reversible, and neutral resiliency	Low	Minor	Not significant	Moderate

Note:
Not significant = minor, moderate; Significant = Major

21.6 CUMULATIVE EFFECTS ASSESSMENT

21.6.1 Scoping Cumulative Effects

21.6.1.1 Valued Components and Project-related Residual Effects

Project-related residual effects are predicted for the human health VC due to the potential for changes in air quality, country foods quality, drinking water quality, and noise. Even if all activity-specific guidelines, mitigation and management plans, best management practices, and laws are strictly adhered to, residual effects and cumulative effects may still occur. Section 21.5 provides a more detailed discussion of the Project residual effects, and all residual effects due to the Project were carried through into the CEA.

21.6.1.2 Defining Assessment Boundaries

Spatial and Temporal Boundaries for Human Health Effects due to Air, Drinking Water, or Country Foods Quality

Similar to the Project-related effects, assessment boundaries define the maximum limit within which the cumulative effects assessment is conducted. Boundaries relevant to human health are described below. The definition of these assessment boundaries is an integral part of the CEA, and encompasses possible direct, indirect, and induced changes of the Project on human health.

The temporal boundaries for the identification of physical projects and activities have been categorized into past, present, and reasonably foreseeable future projects and are defined as follows:

- **Past**: no longer operational projects and activities that were implemented in the past 50 years. This temporal boundary takes into account any far-future effects from past projects and activities[3];
- **Present**: active and inactive projects and activities; and
- **Future**: certain projects and activities that will proceed, and reasonably foreseeable projects and activities that are likely to occur. These projects are restricted to those that 1) have been publicly announced with a defined project execution period and with sufficient project details for assessment; and/or 2) are currently undergoing an environmental assessment, and/or 3) are in a permitting process.

Information on other physical projects and activities has been identified for the Kamloops LRMP boundary[4] as per the commitments in the AIR (see Figure 8.7-1, Chapter 8). However, since the cumulative effects assessment for human health is based on a reasonable expectation of where

---

[3] Far future effects are defined as effects that last more than 37 years, as per Table 8.6-2: Attributes for Characterization of Residual Effects, in Chapter 8, Assessment Methodology.

[4] Note that the CEA area only refers to the spatial boundaries for the identification of other physical projects and activities, i.e., the Kamloops LRMP boundary. Each assessment chapter will define its own spatial and temporal boundaries.

Project residual effects may spatially or temporally overlap with the residual effects of other project and activities, the CEA boundary for human health has been defined as the human health RSA used in the Project residual effects assessment. The cumulative effects assessment area for human health is the RSA shown in Figure 21.6-1.

Spatial and Temporal Boundaries for Human Health Effects due to Changes in Noise Levels

Noise levels will immediately return to baseline levels after Project noise sources are removed. Therefore, the noise CEA only considers projects with construction and/or operation phases that overlap with the Project phases. As such, past projects or activities are not considered, and the assessment will focus on existing and potential future sources of noise.

Noise impacts are typically restricted to within 10 km of the noise source as previously mentioned; therefore, the noise CEA focuses on projects and activities within 10 km of the Project which coincides with the noise RSA. Figure 10.6-1 shows the location of the CEA boundary for assessment of human health due to noise.

21.6.2 Screening and Analyzing Cumulative Effects

Table 21.6-1 presents the projects and activities with the potential to interact cumulatively with the predicted residual effects for human health identified in Table 21.5-12.

21.6.2.1 Potential for Cumulative Effects to Human Health due to Changes in Air Quality

The CEA for human health due to changes in the quality of air quality considers projects and activities with phases that overlap with the Construction and Operations phases of the Project within the human health CEA boundary. Other projects and activities with potential interaction with the Project that may lead to cumulative residual effects to human health due to changes in air quality are identified in Table 21.6-1 and Figures 21.6-1, 21.6-2, 21.6-3, 21.6-4, 21.6-5, and 21.6-6. The same risk ratings used for Project effects on human health due to air quality are used in the CEA, with green indicating low risk interaction, yellow indicating moderate risk interaction, and red indicating high risk interaction.

Residual effects to human health due to changes in air quality Project were identified due to PM_{10} concentrations predicted at only the temporary construction camp for workers during the Construction phase and at the upper snowmobile pullout during the Operations phase. No residual effects are predicted in areas further away from the Project.

Pollutant levels will return to baseline levels after Project emission sources are removed. Therefore, the air quality CEA only considers projects with construction and/or operation phases that overlap with the Project phases. As such, past projects or activities will not be considered, and the assessment will focus on existing and potential future sources of air quality. The Louis Creek Sawmill and the Weyerhaeuser Sawmill are located within the cumulative study area; however, as past projects there are no emissions to overlap with potential effects from the Project. No further consideration is warranted.

Figure 21.6-1

Location of Past, Present and Reasonably Foreseeable Future Projects in the Cumulative Effects Assessment Area for Human Health

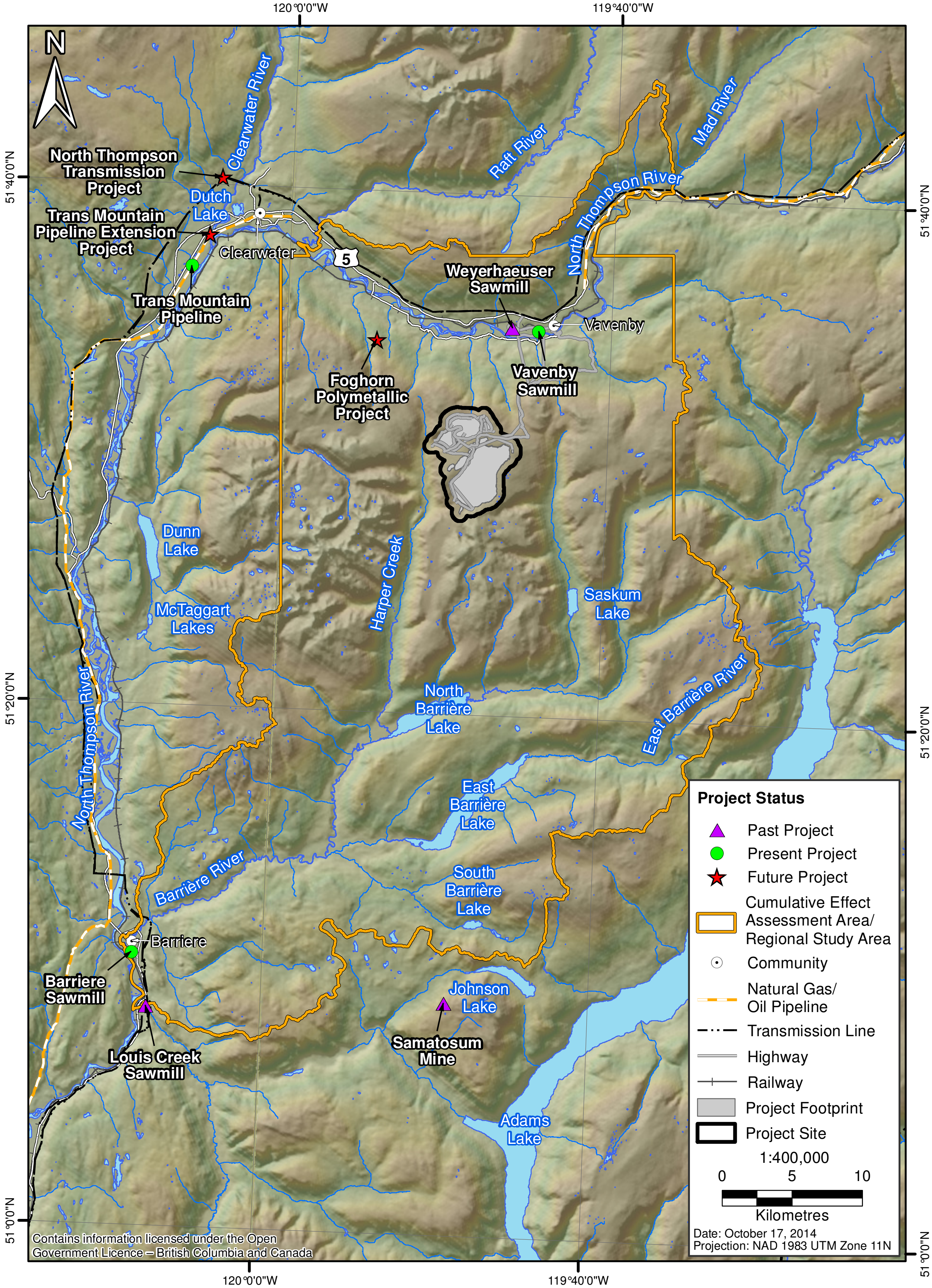


Table 21.6-1. Impact Matrix for Screening and Ranking Potential Cumulative Effects

Residual Effects of the Harper Creek Project on Human Health	Past Projects				Present Projects								Reasonably Foreseeable Future Projects							Activities										
	Weyerhaeuser Sawmill	Samatosum Project	Weyerhaeuser Sawmill	Louis Creek Sawmill	Highland Valley Copper	Bone Creek	Trans Mountain Pipeline	Kamloops Groundwater Project	New Afton	Cache Creek Landfill Extension	Vavenby Sawmill	Barriere Sawmill	North Thompson Transmission Project	Ruddock Creek Project	Trans Mountain Pipeline Expansion	Foghorn Project	Tranquille on the Lake	Shannon Creek	Ajax Project	Aboriginal Harvesting	Hunting	Trapping	Fishing	Non-commercial Recreation	Commercial Recreation	Mineral Exploration	Transportation	Agriculture	Forestry	Water Use
Decrease in air quality (PM_{10}) that could affect human health	🟢		🟢	🟢							🟢	🟢				🟢				🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	
Decrease in quality of country foods that could affect human health in consumers of country foods	🟢		🟢	🟢							🟢	🟢				🟢										🟢	🟢	🟢	🟢	
Decrease in drinking water quality that could affect human health through consumption of surface water	🟢		🟢	🟢							🟢	🟢				🟢										🟢	🟢	🟢	🟢	🟢
Increase in noise levels that could affect human health											🟢					🟢								🟢	🟢	🟢	🟢		🟢	

Notes:

🟢 = *Negligible to minor risk of adverse cumulative effect; will not be carried forward in the assessment.*

🟡 = *Moderate risk of adverse cumulative effect; will be carried forward in the assessment.*

🔴 = *Major risk of adverse cumulative effect or significant concern; will be carried forward in the assessment.*

Figure 21.6-2

Forestry in the Human Health Cumulative Effects Assessment Area

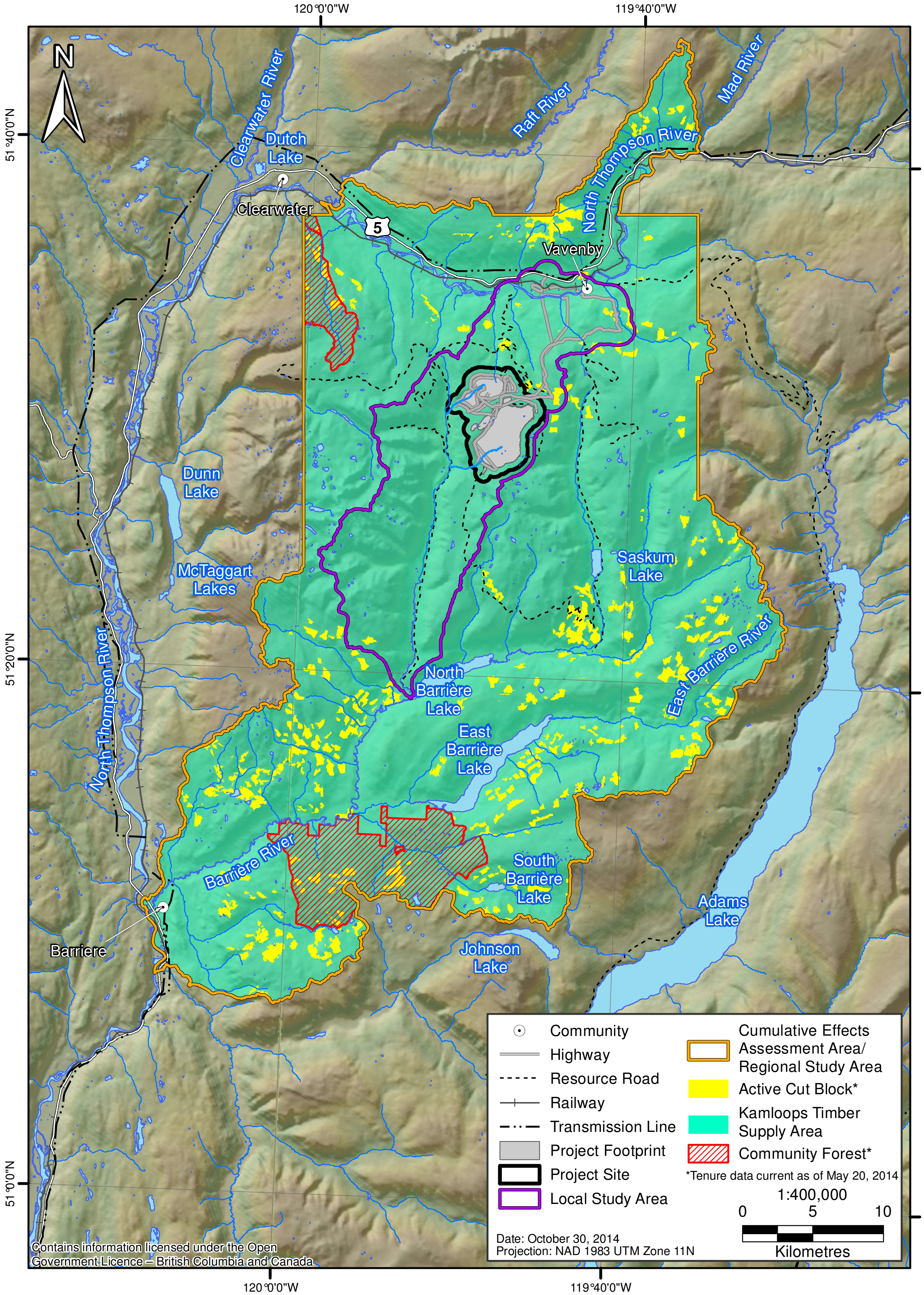


Figure 21.6-3
Commercial Recreation Tenures in the Human Health Cumulative Effects Assessment Area

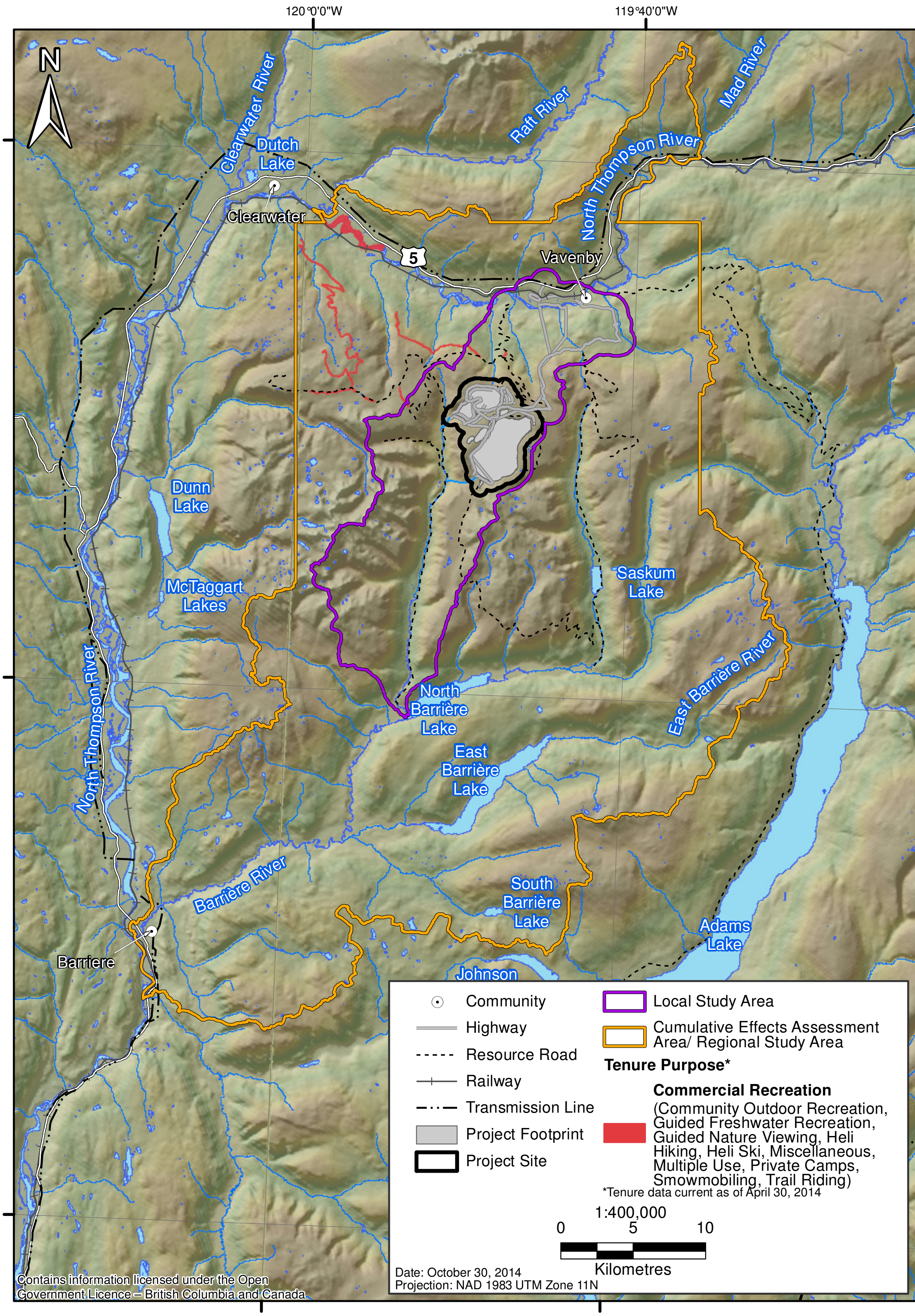


Figure 21.6-4
Water Licences and Range Tenures in the Human Health Cumulative Effects Assessment Area

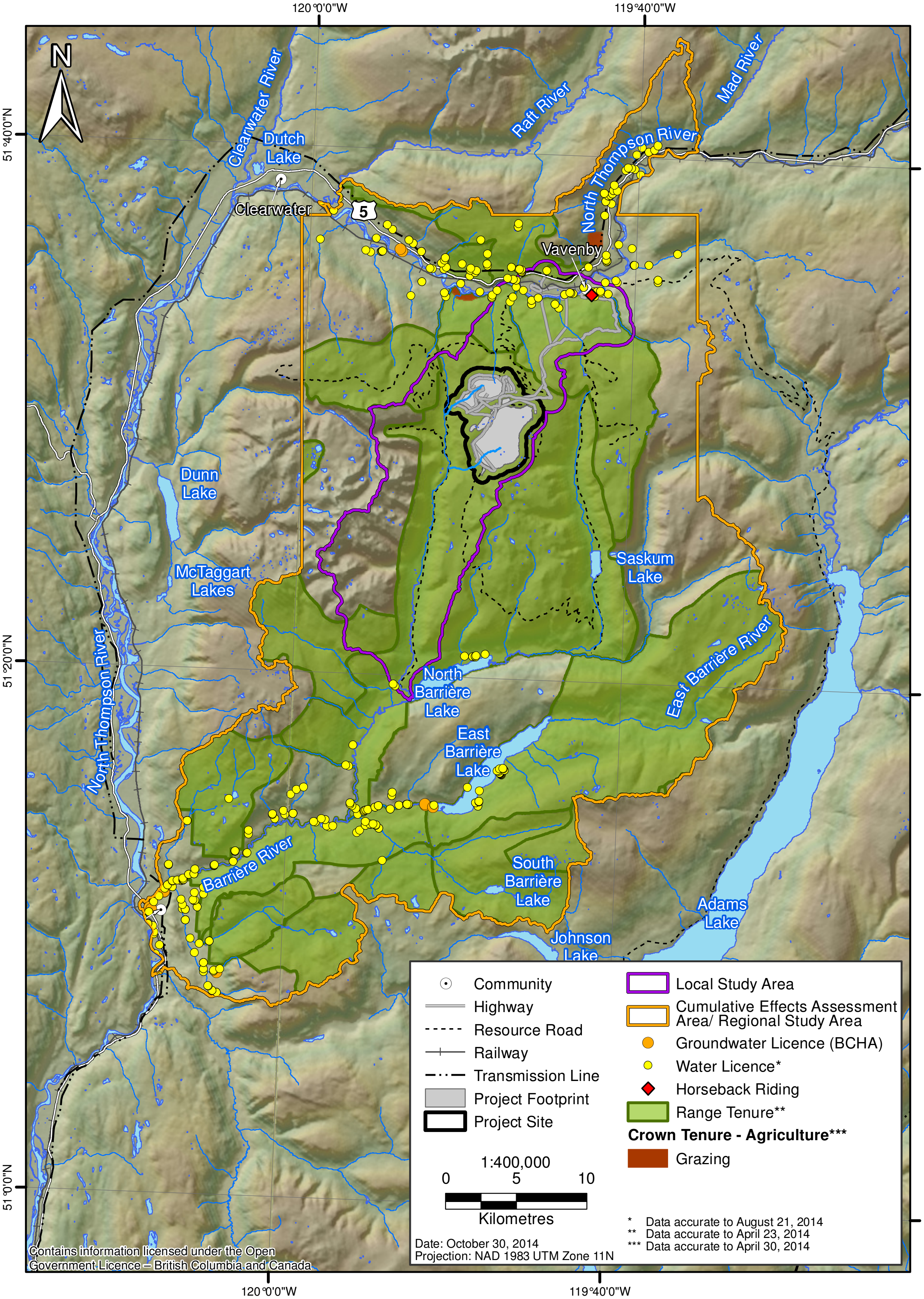


Figure 21.6-5

BC Recreation Sites, Trails, and Private Campgrounds in the Human Health Cumulative Effects Assessment Area

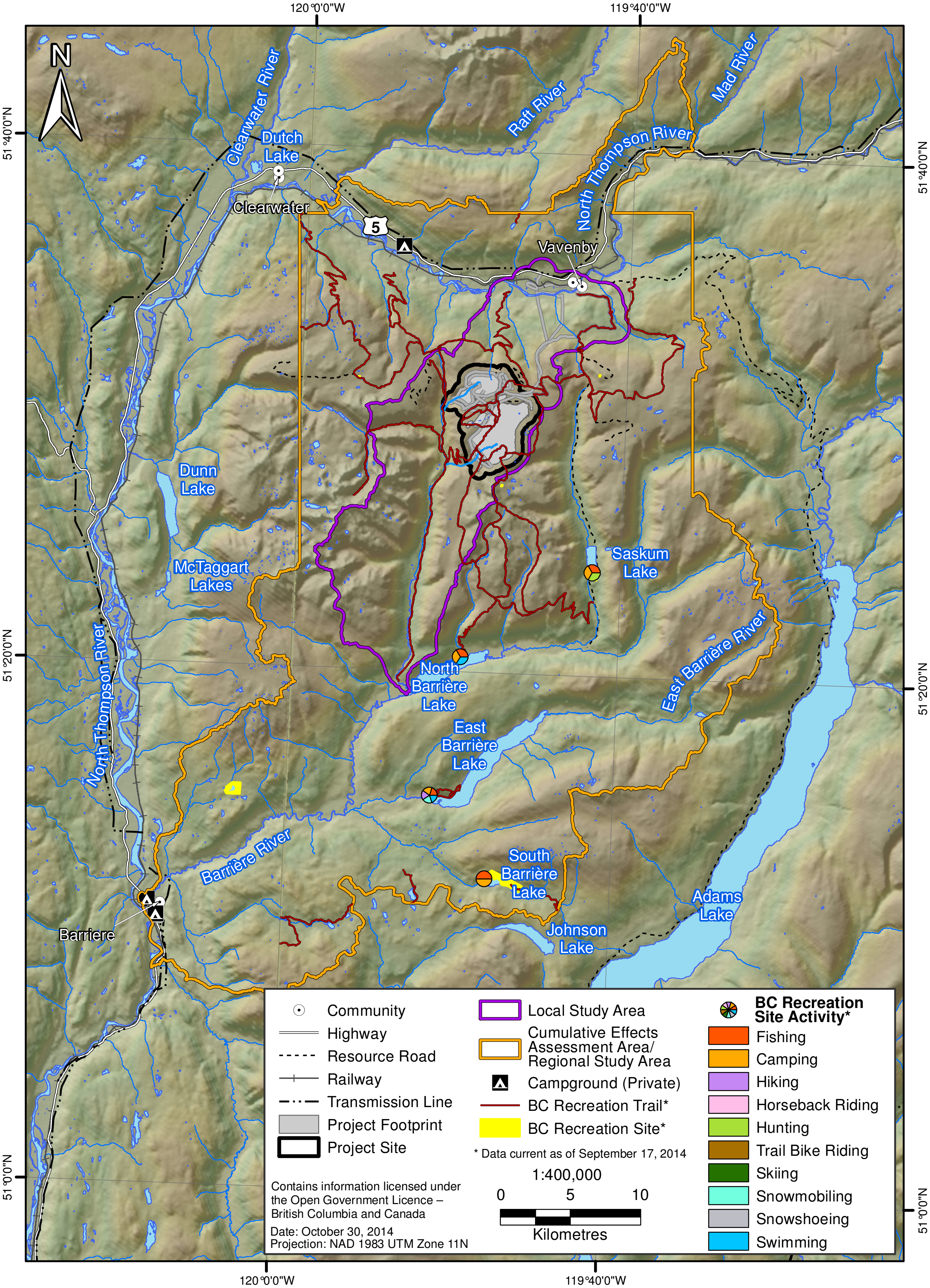
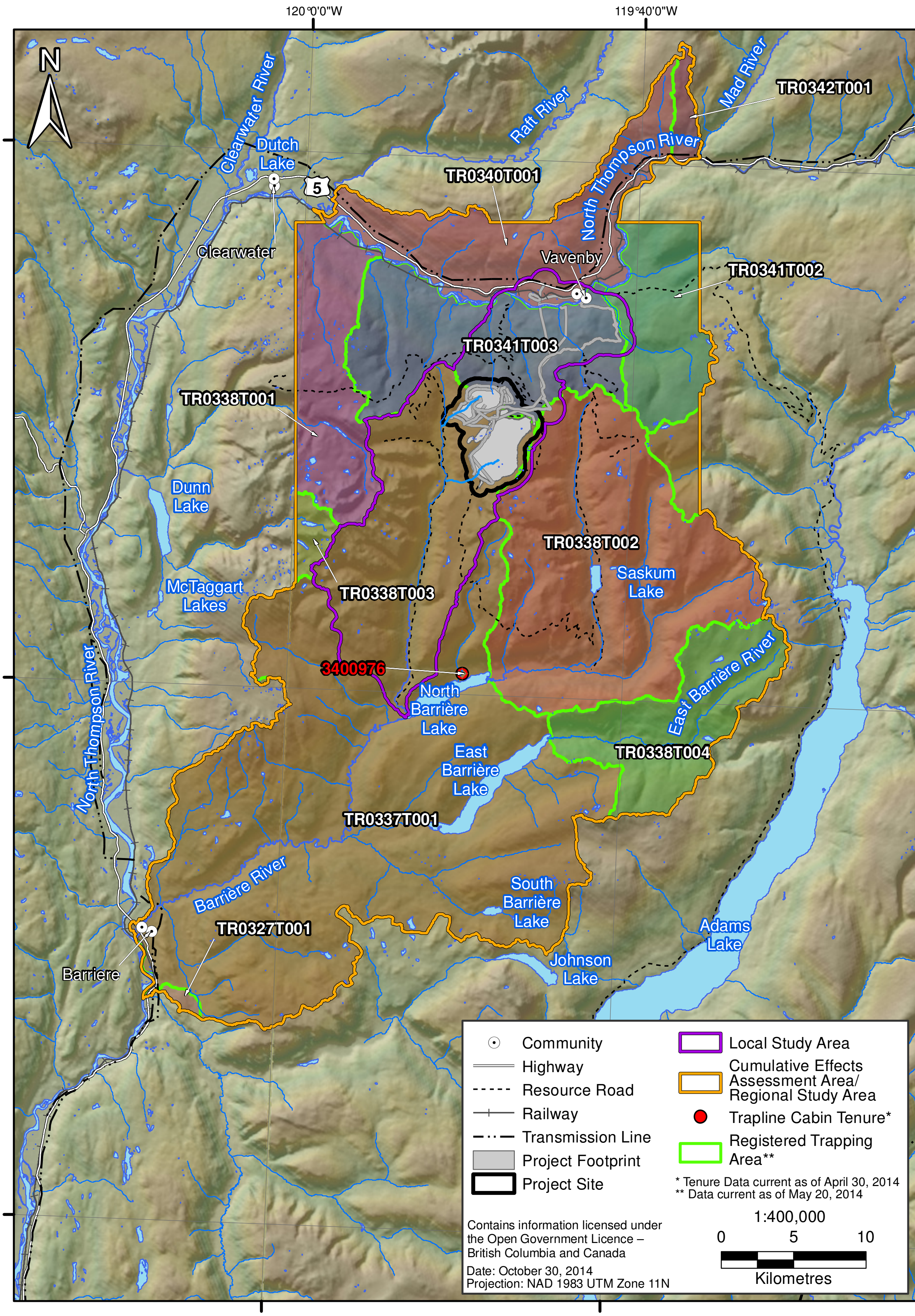


Figure 21.6-6

Trapline Tenures in the Human Health Cumulative Effects Assessment Area



The Vavenby Sawmill is a source of PM_{10} emissions. The emissions from the sawmill, presented in the Baseline Conditions section (Table 9.4-3), are minimal compared to those from the Project, and would not be expected to overlap with the areas in which residual effects are predicted for the Project. Since there is no spatial overlap of effects from the Vavenby sawmill with the residual effects of the Project, no further consideration is warranted.

Land use activities such as hunting, harvesting, fishing, trapping, and utility corridors (Figures 21.6-5 and 21.6-6) would produce negligible air emissions, and therefore there is no cumulative interaction. Other land use activities that could interact temporally with air quality include: forestry (Figure 21.6-2), agriculture (Figure 21.6-4), industrial roads, and mineral exploration. These activities could produce PM10 emissions, primarily due to traffic. The emissions are likely to be short lived and localized. Assuming standard mitigation and management measures are in place, the cumulative impacts are considered negligible. No further consideration is warranted.

The only other reasonably foreseeable future project in the RSA is the Foghorn Polymetallic Project. The Foghorn Polymetallic Project is a mineral claim and proposed uranium mine; however, the project is currently on hold due to a provincial ban on uranium exploration and mining. As previously mentioned, emissions are eliminated immediately after sources are removed. It is uncertain if the Foghorn Polymetallic Project will start construction before the end of the Project's life of mine. As presented in contour figures provided in Appendix 9-E, there are negligible effects from the Project at the location of the proposed Foghorn Polymetallic Project. Therefore, it is unlikely that the Foghorn Polymetallic Project and Project will interact to create a cumulative residual effect on human health. Due to the low likelihood of a cumulative residual adverse effect, and the unknown timeline of the Foghorn Polymetallic Project, further assessment is not warranted.

21.6.2.2 Potential for Cumulative Effects to Human Health due to Changes in Country Foods Quality

The CEA for human health due to changes in the quality of country foods considers projects and activities with phases that overlap with all four of the Project phases within the human health CEA boundary. Other projects and activities with potential interaction with the Project that may lead to cumulative residual effects to human health due to changes in the quality of country foods are identified in Table 21.6-1 and Figures 21.6-1, 21.6-2, 21.6-3, 21.6-4, 21.6-5, and 21.6-6. The same risk ratings used for Project effects on country foods are used in the CEA, with green indicating low risk interaction, yellow indicating moderate risk interaction, and red indicating high risk interaction.

Cumulative effects on human health from country foods were assessed by considering the following components:

- the potential for cumulative effects on country foods quality due to water quality; and
- the potential for cumulative increases in dust and metals deposition onto plants and soils (due to changes in air quality, specifically fugitive dust).

Other projects that may have spatial interaction with the Project are:

- the past Louis Creek Sawmill;
- the past Weyerhaeuser Sawmill;

- the present Vavenby Sawmill;
- the present Barriere Sawmill; and
- the proposed Foghorn Polymetallic Project.

Cumulative effects from past projects (e.g., the Louis Creek and Weyerhaeuser sawmills) are included in the baseline assessment for country foods, and no additional future cumulative effects are expected; they are not considered further.

Based on the information provided in Chapter 8, Assessment Methodology (Section 8.7.1.3) about the durations and timelines for other projects and activities, the Project timeline is expected to overlap temporally with the following projects:

- the present Vavenby Sawmill;
- the present Barriere Sawmill; and
- the proposed Foghorn Polymetallic Project.

Activities such as Aboriginal harvesting, hunting, trapping, fishing, non-commercial and commercial recreation (Figures 21.6-3, 21.6-5, and 21.6-6) are unlikely to affect the quality of water and would not increase dust and metal deposition, thus there is no cumulative effect from these activities and they will not be considered further.

<u>Potential for Water Quality to Affect Country Foods Quality</u>

No interactions are expected for the Vavenby and Barriere sawmills, since any potential water quality effects from these projects will be local and do not spatially overlap with the Project residual effects to water quality which are limited to P, T, and Harper creeks.

The only reasonably foreseeable future project in the RSA is Foghorn Polymetallic Project located in the northwest corner of the RSA. The Foghorn Polymetallic Project is a mineral claim and proposed uranium mine with the potential for future work mining other commodities including fluorite, celestite, rare earth metals, and molybdenum; however, the project is currently on hold due to a provincial ban on uranium exploration and mining. At this time, the expected ban removal or project start timeline is unknown. It is uncertain if the Foghorn Polymetallic Project will start construction before the end of Harper Creek Project's life-of-mine. The Foghorn Polymettalic Project is located in an area where Project effects on water quality are not expected to occur. Due to the unknown timeline of the Foghorn Polymetallic Project and the lack of spatial overlap with Project residual effects, further assessment is not warranted. Therefore, cumulative effects on country foods quality due to changes in water quality are not expected and no further consideration is warranted.

Activities such as mineral exploration, transportation, agriculture, forestry, and water use (Figures 21.6-2 and 21.6-4) may have effects on water quality. However, Project-related residual effects on surface water quality beyond P, T, and Harper creeks were not predicted and effects on the quality of country foods would not be expected.

<u>Potential for Cumulative Dusting and Metal Deposition to Affect Country Foods Quality</u>

The construction of the Foghorn Polymetallic Project is the only project in the reasonably foreseeable future that could have cumulative effects on air quality; however, due to the unknown timeline for that project further assessment is not warranted. Dust deposition from the Project is highly localized to the Project Site and along the access roads, thus it is expected that there will be no cumulative effects from dust deposition on soils and vegetation in areas suitable for country foods harvesting or for wildlife consumption.

Other land use activities that would interact temporally with air quality include: forestry activities, agriculture activities, industrial roads and mineral exploration (Figures 21.6-2 and 21.6-4). These activities could produce dust, primarily due to traffic on unpaved roads. The emissions are likely to be short lived and localized, however. Assuming standard mitigation and management measures are in place, the cumulative impacts are considered negligible. No further consideration is warranted.

<u>Summary of Potential for Cumulative Effects to Human Health due to Changes in Country Foods Quality</u>

No potential cumulative effects to human health due to changes in country foods were identified (taking into consideration potential for changes in water quality and air quality) based on assessment of potential interactions of the Project with other projects or activities in the CEA boundary. No further consideration of the potential for cumulative effects to human health due to consumption of country foods is warranted.

21.6.2.3 Potential for Cumulative Effects to Human Health due to Changes in Drinking Water Quality

The only location where there Project-related effects to drinking water quality were identified is in T Creek. Cumulative effects from past projects (e.g., the Louis Creek and Weyerhaeuser sawmills) are included in the baseline assessment for water quality, and no additional future cumulative effects are expected; they are not considered further.

No interactions are expected for the Vavenby and Barriere sawmills, since any potential water quality effects from these projects will be local and do not spatially overlap with the Project residual effects to water quality which is limited to T Creek.

Activities such as mineral exploration, transportation, agriculture, forestry, and water use (Figures 21.6-2 and 21.6-4) may have effects on water quality in the wider CEA boundary. However, Project-related residual effects on surface water quality beyond T Creek were not predicted, and these effects to water quality associated with these activities would have limited or no spatial overlap with water quality in T Creek.

The only reasonably foreseeable future project in the RSA is Foghorn Polymetallic Project located in the northwest corner of the RSA. The Foghorn Polymetallic Project is a mineral claim and proposed uranium mine with the potential for future work mining other commodities including fluorite, celestite, rare earth metals, and molybdenum; however, the project is currently on hold due to a provincial ban on uranium exploration and mining. At this time, the expected ban removal or project start timeline is unknown. It is uncertain if the Foghorn Polymetallic Project will start construction before the end of Harper Creek Project's life-of-mine. The Foghorn Polymettalic Project is located in an area where Project-related effects on water quality are not expected to occur and is unlikely to interact spatially with the area where Project residual effects are predicted to occur (i.e., T Creek). Due to the unknown timeline of the Foghorn Polymetallic Project and the lack of spatial overlap with Project residual effects, further assessment is not warranted. Therefore, cumulative effects on human health due to changes in drinking water quality are not expected.

21.6.2.4 Potential for Cumulative Effects to Human Health due to Changes in Noise Levels

As described in Chapter 10, Section 10.6.1.2, noise levels will immediately return to baseline levels after Project noise sources are removed and impacts are restricted to within 10 km of the sources (i.e., within the CEA boundary). Project residual effects to human health due to changes in noise level were identified at only a few human receptor locations in close proximity to the Project Site or infrastructure (Section 21.5.3.4).

Since noise will return to baseline once Project noise sources are removed, the noise CEA only considers projects with construction and/or operation phases that overlap with the Project phases within the CEA boundary, or activities that are existing and that are emitting noise.

Projects and activities with the potential to interact with the Harper Creek Project that may lead to cumulative residual effects on noise are identified in Table 21.6-1. The same risk ratings used for Project effects on noise are used in CEA, with green indicating low risk interaction, yellow indicating moderate risk interaction, and red indicating high risk interaction.

Activities such as trapping, hunting, harvesting, fishing, use of recreation or private cabins, camping, trail riding or hiking, water extraction, and utility corridors (Figures 21.6-4, 21.6-5, and 21.6-6) would produce negligible noise levels compared to noise levels as a result of the Project and therefore there is no cumulative interaction. For activities such as transportation, guided freshwater recreation, and snowmobiling (Figures 21.6-3 and 21.6-5), a perceptible noise would be produced. However, since the noise baseline monitoring was conducted in 2012, baseline noise levels already include all the existing activities. Moreover, noise from guided freshwater recreation and snowmobiling is expected to be transient and therefore, the interaction is limited to minutes. Although there is an interaction with transportation and forestry activities (Figure 21.6-2), the interaction and effect of existing activities producing noise are already accounted for in the noise baseline assessment, so no cumulative effects would be expected from any of these activities

Vavenby Sawmill is the only existing project inside the noise CEA area. Historically, there was a Wyerhaeuser Sawmill operating nearby the Vavenby Sawmill; however, the Wyerhaeuser Sawmill has been closed since 2003 with no plans for resuming operation. The property, now owned by Yellowhead Mining Inc., is proposed for use as the concentrate load-out facility (interim storage and reclaim) for the Project. The potential noise sources from Vavenby Sawmill may include lumber processing and traffic along the access road. Since the Traffic Impact Assessment (Appendix 5-E) was conducted in 2014, the existing traffic presented in the assessment already includes the traffic from the Vavenby Sawmill. Moreover, the baseline noise monitoring conducted in 2012 would also include noise sources from Vavenby Sawmill. Lumber processing noise is considered to be localized enough that no spatial overlap would be occur with the human receptor locations where Project residual effects due to noise were identified; no cumulative effects would be expected since there is no spatial overlap.

The only other reasonably foreseeable future project in the noise CEA area is the Foghorn Polymetallic Project. As previously mentioned, noise effects diminish immediately after the source(s) are removed. It is uncertain if the Foghorn Polymetallic Project will start construction before the end of Harper Creek Project's Operations phase. As presented in Chapter 10, Figures 10.5-2 to 10.5-6, the limit for speech interference of 55 dBA is only expected to be reached within metres of the sources. Therefore, it is unlikely that the Foghorn Polymetallic Project and Harper Creek Project will interact to create a cumulative residual adverse effect on human health due to noise levels, even if the Foghorn Polymetallic Project were to become active during the Operation phase of the Harper Creek Project. No further assessment of cumulative effects on human health would be expected and additional consideration is not warranted.

21.6.2.5 Summary of the Potential for Cumulative Effects on Human Health

Based on the preceding assessment (Sections 21.6.2.1 to 21.6.2.4), no potential cumulative effects to human health due to changes in air quality, country foods quality, drinking water quality, and noise levels were identified. Therefore, no additional mitigation measures were identified and no characterization of cumulative residual effects is required.

21.7 CONCLUSIONS FOR HUMAN HEALTH

A summary of the assessment of effects to human health due to changes in air quality, country foods quality, drinking water quality, and noise is presented in Table 21.7-1.

Human health is a highly valued component for each individual and for society. The assessment included several different pathways through which health can be affected: the inhalation of air, the ingestion of country foods, ingestion of water, and the effects of noise. It is recognized that health is more than just physical well-being. For instance, social, cultural, nutritional, and economic factors also play in a person's overall health status. These health indicators have been assessed in other sections of the EIS. Chapter 21 followed a science-based approach recommended by Health Canada to assess the potential for people to experience adverse health effects by exposure to contaminants of potential concern in air, country foods, and drinking water, and exposure to noise.

The assessment focused on residents, and temporary and seasonal land users. While workers' health is covered under Occupational Health and Safety Plans (as required by regulation and policy), consideration of the health of off-duty workers was included in the assessment, as recommended by Health Canada.

The human health assessment relied on data measured during baseline studies, and future modelled predictions of noise levels, air quality, and water quality. These predicted data were used to assess potential effects of the proposed Project on human health. There can be uncertainties associated with the models and, therefore, conservative assumptions were made wherever possible. This likely resulted in an overestimation of human health risks.

Table 21.7-1. Summary of Key Project and Cumulative Residual Effects, Mitigation, and Significance for Human Health

Residual Effects	Project Phase	Mitigation Measures	Significance of Residual Effects: Project	Significance of Residual Effects: Cumulative
Human Health due to a Change in Air Quality				
Decrease in air quality that could affect human health	Construction and Operations	Air Quality Management Plan, including mitigation measures to decrease air emissions	Not significant (minor)	Not significant (minor)
Human Health due to a Change in Country Foods Quality				
Decrease in country foods quality that could affect human health in consumers of country foods	All phases	No hunting, fishing, or berry collecting at the Project Site; various management plans to minimize risk to environmental quality (e.g., air, water, soil, and vegetation quality) or VCs that are used as country foods (e.g., fish or wildlife)	Not significant (minor)	Not significant (minor)
Human Health due to a Change in Drinking Water Quality				
Decrease in drinking water quality that could affect human health through consumption of water	Closure and Post-closure	Various management plans to minimize the changes in water quality (e.g., Fish and Aquatic Effects Monitoring and Management Plan; Groundwater Monitoring and Management Plan; Mine Waste and ML/ARD Management Plan; Sediment and Erosion Control Plan)	Not significant (minor)	Not significant (minor)
Human Health due to a Change in Noise Levels				
Increase in noise levels that could affect human health	Construction and Operations	Consider noise in equipment selection, adequate maintenance, reducing vehicle speed, avoid idling, and optimize construction design and site layout	Not significant (minor)	Not significant (minor)

The Project may have residual effects to human health due to air quality during the Construction and Operations phases, due to elevated PM_{10} levels at several human receptor locations on or in close proximity to the Project Site. Residual effects to human health due to changes in air quality Project were identified due to PM_{10} concentrations predicted at only the temporary construction camp for workers during the Construction phase and at the upper snowmobile pullout during the Operations phase. No residual effects are predicted in areas further away from the Project. The magnitude of the residual effects is negligible, since the effect to human health is not predicted to be different than it is during baseline conditions; therefore, the residual effect is **not significant (minor)**.

The cumulative effects assessment for human health due to air quality found that there were few other projects or activities that had spatial or temporal overlap. It is unlikely that changes in air quality due to other projects or activities would interact or change the residual effects of the Project.

Therefore, the potential for cumulative effects is considered to be the same as the Project residual effects (i.e., no cumulative effects) and is **not significant (minor)**.

Human health effects from the ingestion of country foods were assessed for all phases of the Project. Since the human health effects assessment due to the consumption of country foods was qualitative or semi-quantitative rather than fully quantitative, it was carried forward as a residual effect; however, the magnitude was considered to be negligible and the Project residual effects were not significant (minor). Cumulative human health residual effects due to ingestion of country foods are not expected, since relatively few projects or activities have spatial or temporal overlap with the Project residual effects, and are considered to be **not significant (minor)**.

Potential residual effects to human health due to drinking water quality were identified due to changes in water quality (elevated selenium concentrations) during the Closure and Post-Closure phases. However, there are no regular drinking water users of T Creek (no surface water licenses), and transient user of T Creek as a source of drinking water would not be expected to cause effects to human health. Therefore, the residual effect was determined to have a negligible magnitude and was assessed to be **not significant (minor)**. No other projects or activities were found to have spatial or temporal overlap with the Project residual effects to drinking water quality, which are limited to T Creek, therefore, the potential for cumulative effects is considered to be the same as the Project residual effects (i.e., no cumulative effects) and is **not significant (minor)**.

During the construction of the mine infrastructure, noise levels greater than the speech interference criterion are predicted at the potential upper pullout area for snowmobiles. However, people are only expected to be present at the pullout area for a few minutes while on a (noisy) idling snowmobile as they wait for haul trucks to pass on the road. Considering the intended use of the location, the elevated noise levels are not likely to have any effect on human health; therefore, the magnitude is considered negligible. The significance of the residual effect on noise during the Construction phase is considered to be **not significant (minor)**. During the Operations phase, predicted noise levels from mining activities are predicted to be greater than the criterion for speech interference at the upper and lower potential pullout areas for snowmobiles. Considering the intended use of the locations, effects to human health were assessed to be negligible. The significance of residual effect on human health due to noise during the Operations phase is considered to be **not significant (minor)**.

The cumulative effects assessment for human health due to noise found that there were few other projects or activities that had spatial or temporal overlap with the Project residual effects. It is unlikely that changes in air quality due to other projects or activities would interact or change the residual effects of the Project. Therefore, the potential for cumulative effects is considered to be the same as the Project residual effects (i.e., no cumulative effects) and is **not significant (minor)**.

Overall, the assessment of potential effects to human health due to changes in air quality, country foods quality, drinking water quality, or noise levels found that both Project residual effects and cumulative effects are **not significant (minor)**.

REFERENCES

1992. *Canadian Environmental Assessment Act*, SC. C. c. 37.

1996. *BC Wildlife Act*, RSBC 1996. C. 488.

1999. *Canadian Environmental Protection Act*, SC. C. c. 33.

2001. *British Columbia Drinking Water Protection Act*, SBC. C. c. 9.

2002. *Environmental Assessment Act*, SBC. C. c. 43.

2003. *Environmental Management Act*, SBC. C. c. 53.

BC Municipal Wastewater Regulation, B.C. Reg 87/2012.

Hazardous Waste Regulation, *Environmental Management Act*, B.C. Reg. 63/88.

Open Burning Smoke Control Regulation, *Environmental Management Act*, B.C. Reg. 145/93.

Ground Water Protection Regulation, B.C. Reg. 299/2004.

British Columbia Drinking Water Protection Regulation, BC Reg. 200/2003.

Occupational Health and Safety Regulation, BC Reg. 296/97.

Waste Discharge Regulation, BC Reg. 320/2004.

Alberta ERCB. 2007. *Directive 38: Noise Control* Energy Resources Conservation Board: Calgary, AB.

ALS Environmental. 2013. *Lab Science News - Technical Blog: Sample Containers & Preservation for Mercury Analysis in Waters*. http://www.caslab.com/News/sample-containers-preservation-for-mercury-analysis-in-waters.html (accessed July 2014).

ATSDR. 2004. *Toxicological Profile For Cobalt*. Prepared by the Agency for Toxic Substances and Disease Registry: Atlanta, GA.

ATSDR. 2008. *Toxicological Profile for Aluminum*. Prepared by the Agency for Toxic Substances and Disease Registry: Atlanta, GA.

BC EAO. 2011. *Harper Creek Copper-Gold-Silver Project: Application Information Requirements for Yellowhead Mining Inc.'s Application for an Environmental Assessment Certificate*. Issued by the British Columbia Environmental Assessment Office: Victoria, BC.

BC ILMB. 1995. *Kamloops Land and Resource Management Plan*. http://www.for.gov.bc.ca/tasb/slrp/lrmp/kamloops/kamloops/plan/files/klrmp_full.pdf (accessed May 2014).

BC MEMPR. 2008. *Health, Safety and Reclamation Code for Mines in British Columbia*. British Columbia Ministry of Energy, Mines, and Petroleum Resources (BC MEMPR); Mining and Minerals Division: Victoria, BC.

BC MFLNRO. 2013. *Recreation Sites and Trails BC - BC's Backcountry Playground*. http://www.sitesandtrailsbc.ca/about/managing-recreation-sites-and-trails.aspx (accessed July 2014).

BC MHP and BC MHS. 2002. *Action Plan for Safe Drinking Water in British Columbia*. British Columbia Ministry of Health Planning and British Columbia Ministry of Health Services: Victoria, BC.

BC MOE. 1979. *Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia*. British Columbia Ministry of Environment: Victoria, BC.

BC MOE. 2008. *Guidelines for Air Quality Dispersion Modelling in British Columbia*. BC Ministry of Environment: Victoria, BC.

BC MOE. 2011. *Proposed Small Electrical Power Generating Facility Code of Practice*. British Columbia Ministry of Environment. http://env.gov.bc.ca/epd/codes/sepgf/index.htm (accessed July 2014).

BC MOE. 2013a. *BC Ambient Air Quality Objectives - Updated August 12, 2013*. British Columbia Ministry of Environment. http://www.bcairquality.ca/reports/pdfs/aqotable.pdf (accessed September 2013).

BC MOE. 2013b. *Guidance for the Derivation and Application of Water Quality Objectives in British Columbia*. Water Protection and Sustainability Branch, Environmental Sustainability and Strategic Policy Division, Ministry of Environment: Victoria, BC.

BC MOE. 2013c. *Levels of Government Involved*. BC Air Quality. http://www.bcairquality.ca/regulatory/levels-of-government.html (accessed May 2013).

BC MOE. 2013d. *Ministry of Environment. Water Stewardship Division*. http://www.env.gov.bc.ca/wsd/index.html (accessed May 2013).

BC MOE. 2013e. *New Ambient Air Quality Criteria for PM2.5: Development Process*. British Columbia Ministry of Environment. http://www.bcairquality.ca/regulatory/pm25-development.html (accessed May 2013).

BC MOE. 2013f. *Summary of Air Quality Legislation*. British Columbia Ministry of Environment. http://www.bcairquality.ca/regulatory/air-legislation-summary.html (accessed May 2013).

BC MOE. 2013g. *Tier 1 Ecological Risk Assessment Policy Decision Summary*. British Columbia Ministry of Environment. http://www.env.gov.bc.ca/epd/remediation/standards_criteria/standards/tier1policy.htm (accessed August 2013).

BC MOE. 2013h. *Water Quality Guidelines (Criteria) Reports*. British Columbia Ministry of Environment, Environmental Protection Division. http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html#working (accessed May 28, 2013).

BC MWLAP and Environment Canada. 2003. *Particulate Matter in British Columbia: A Report on PM_{10} and $PM_{2.5}$ Mass Concentrations up to 2000.* British Columbia Ministry of Water, Land and Air Protection and the Pacific and Yukon Region of Environment Canada: Victoria, BC.

Beatty, J. M. and G. A. Russo. 2014. *Ambient Water Quality Guidelines for Selenium Technical Report Update*. British Columbia Ministry of Environment, Water Protection and Sustainability Branch, Environmental Sustainability and Strategic Policy Division: n.p.

CCME. 1999. *Canadian National Ambient Air Quality Objectives: Process and Status*. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment: Winnipeg, MB.

CCME. 2012. *Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone*. Canadian Council of Ministers of the Environment: Winnipeg, MB.

CCME. 2013a. *Canadian Air Quality Guidelines for the Protection of Human Health and the Environment: Summary Table*. Canadian Council of Ministers of the Environment. http://st-ts.ccme.ca/ (accessed April 2013).

CCME. 2013b. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (Agricultural): Summary Table*. Environment Canada. Canadian Council of Ministers of the Environment. http://st-ts.ccme.ca/ (accessed May 2013).

CCME. 2013c. *Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table*. Environment Canada. Canadian Council of Ministers of the Environment. http://st-ts.ccme.ca/ (accessed April 2013).

CEAA. 2011. *Background Information for the Initial Federal Public Comment Period on the Comprehensive Study pursuant to the Canadian Environmental Assessment Act of the Harper Creek Mine Project near Kamloops, British Columbia*. Canadian Environmental Assessment Agency: Ottawa, ON.

Chan, L., O. Receveur, D. Sharp, H. Schwartz, A. Ing, and C. Tikhonov. 2011. *First Nations Food, Nutrition & Environment Study (FNFNES): Results from British Columbia (2008/2009)*. University of Northern British Columbia: Prince George, BC.

Cheng, L., H. S. Sandhu, R. P. Angle, K. M. McDonald, and R. H. Myrick. 2000. Rural particulate matter in Alberta, Canada. *Atmospheric Environment*, 28 (12): 2061-80.

City of Kamloops. 2012. *Airshed Management Plan*. http://www.city.kamloops.bc.ca/environment/pdfs/13-05-AirshedManagementPlan.pdf (accessed May 2014).

Data BC. 2014. *Geographic Data Discovery Service. Water Intakes (Extraction Points) for Human Consumption – BC*. Government of British Columbia, Ministry of Environment. ftp://ftp.geobc.gov.bc.ca/pub/outgoing/Takla_Lake_FN/BCHA_DW_EP.html (accessed April 2014).

District of Barriere. 2011. *Barriere Official Community Plan*. Schedule "A" of Bylaw No. 1446. Barriere, BC.

District of Clearwater. 2012. *Official Community Plan, 2012*. Schedule "A". Bylaw No. 93. Clearwater, BC.

Ecological Society of America and the Union of Concerned Scientists. 2014. *Water Purification Fact Sheet*. http://www.esa.org/ecoservices/comm/body.comm.fact.wate.html (accessed August 2014).

Environment Canada. 2013. *Backgrounder: Canadian Ambient Air Quality Standards*. http://www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=A4B2C28A-2DFB-4BF4-8777-ADF29B4360BD (accessed April 2014).

Environment Canada. 2014. *National Pollutant Release Inventory*. http://ec.gc.ca/inrp-npri/donnees-data/index.cfm?do=facility_substance_summary&lang=en&opt_npri_id=0000007844&opt_report_year=2013 (accessed September 2014).

ERM Rescan. 2014a. *DRAFT Harper Creek Project: Land Water and Resource Use Effects Assessment*. Yellowhead Mining Inc.: Vancouver, BC.

ERM Rescan. 2014b. *Harper Creek Project: Métis Nation BC Consultation Report*. Prepared for Harper Creek Mining Corporation by ERM Consultants Canada Ltd.: Vancouver, BC.

Golder Associates Ltd. 2002. *Snap Lake Diamond Project Environmental Assessment Report*. Prepared for De Beers Canada Inc. by Golder Associates Ltd.: Calgary, AB.

Golder Associates Ltd. 2005. *Guidance for Including Country Foods in Human Health Risk Assessments for Federal Contaminated Sites*. 04-1412-041. Prepared for Health Canada: Burnaby, BC.

Harper Creek Mining Corp. 2013a. *Harper Creek Project Application for an Environmental Assessment Certificate, Part C, Section 6.6: Water Quality Assessment of Environmental Effects*. Application for an Environmental Assessment Certificate and Environmental Impact Statement for the Comprehensive Study of the Proposed Harper Creek Project. Harper Creek Mining Corp.: Vancouver, BC.

Harper Creek Mining Corp. 2013b. *Harper Creek Project Application for an Environmental Assessment Certificate, Part C, Section 6.8: Vegetation and Wildlife Assessment of Environmental Effects*. Application for an Environmental Assessment Certificate and Environmental Impact Statement for the Comprehensive Study of the Proposed Harper Creek Project. Harper Creek Mining Corp.: Vancouver, BC.

Harper Creek Mining Corp. 2013c. *Harper Creek Project Application for an Environmental Assessment Certificate, Part C, Section 7.2: Land, Water, and Resource Use*. Application for an Environmental Assessment Certificate and Environmental Impact Statement for the Comprehensive Study of the Proposed Harper Creek Project. Harper Creek Mining Corp.: Vancouver, BC.

Harris Miller Miller & Hanson Inc. 2006. *Transit Noise and Vibration Impact Assessment*. FTA-VA-90-1003-06. Prepared for the US Federal Transit Administration, Office of Planning and Environment: Washington, DC.

HCMC. 2013. *Application for an Environmental Assessment Certificate and Environmental Impact Statement for the Comprehensive Study of the Proposed Harper Creek Project*. Harper Creek Mining Corporation: Vancouver, BC.

Health Canada. 1996. *Guidelines for Canadian Drinking Water Quality, Part II: Supporting Documentation*. Health Canada: Ottawa, ON.

Health Canada. 1999a. *Canadian Handbook on Health Impact Assessment Volume 1: The Basics*. A report of the Federal/Provincial/Territorial Committee on Environmental and Occupational Health: Ottawa, ON.

Health Canada. 1999b. *National Ambient Air Quality Objectives for Particulate Matter - Addendum to the Science Assessment Document. Particulate Matter ≤ 10 µm and ≤ 2.5 µm*. A report by the Federal-Provincial Working Group on Air Quality Objectives and Guidelines: Ottawa, ON.

Health Canada. 2007. *Human Health Risk Assessment of Mercury in Fish and Health Benefits of Fish Consumption*. Bureau of Chemical Safety, Food Directorate, Health Products and Food Branch: Ottawa, ON.

Health Canada. 2008. *Drinking Water in The Great Canadian Outdoors*. Health Canada. http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/outdoor-plein_air-eng.php (accessed June 2013).

Health Canada. 2009a. *DRAFT: Supplemental Guidance on Human Health Risk Assessment on Air Quality (HHRAAIR)*. Contaminated Sites Division, Health Canada: Ottawa, ON.

Health Canada. 2009b. *Safe Handling of Fresh Fruits and Vegetables*. http://www.hc-sc.gc.ca/hl-vs/alt_formats/pacrb-dgapcr/pdf/iyh-vsv/food-aliment/handling-manipulation-eng.pdf (accessed April 2013).

Health Canada. 2010a. *Draft Federal Contaminated Site Risk Assessment in Canada, Supplemental Guidance on Human Health Risk Assessment for Country Foods (HHRAFOODS)*. Version 1.2 (Draft). Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2010b. *Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)*. Version 2.0. Revised 2012. Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2010c. *Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors*. Version 2.0. Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2010d. *Federal Contaminated Site Risk Assessment in Canada, Supplemental Guidance on Human Health Risk Assessment for Country Foods (HHRAFoods)*. Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2010e. *Useful Information for Environmental Assessments*. 978-1-001-15153-3. Health Canada, Environmental Assessment Division: Ottawa, ON.

Health Canada. 2011a. *DRAFT: Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise*. Environmental Health Bureau, Healthy Environments and Consumer Safety Branch: Ottawa, ON.

Health Canada. 2011b. *Toxicological Reference Values, Estimated Daily Intakes or Dietary Reference Values for Trace Elements. Obtained from Chemical Health Hazard* Revised March 2011, unpublished: Ottawa, ON.

Health Canada. 2012. *Guidelines for Canadian Drinking Water Quality - Summary Table*. Water, Air and Climate Change Bureau, Healthy Environments and Consumer Safety Branch, Health Canada: Ottawa, ON.

International Snowmobile Manufacturers Association. 2014. *Snowmobile Fact Book: Sound & Environment*. http://www.snowmobile.org/facts_sound.asp (accessed August 2014).

JECFA. 1972. *Cadmium*. Presented at Joint FAO/WHO Expert Committee on Food Additives (JECFA), n.p.

JECFA. 1982. *Zinc*. Presented at Joint FAO/WHO Expert Committee on Food Additives (JECFA), n.p.

JECFA. 2000. *Lead. Safety Evaluation of Certain Food Additives and Contaminants. Prepared by the Fifty-third meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA)*. Joint

FAO/WHO Expert Committee on Food Additives (JECFA). http://www.inchem.org/documents/jecfa/jecmono/v44jec12.htm (accessed March 2013).

JECFA. 2005. *Cadmium. Summary of Evaluations Performed by the Join FAO/WHO Expert Committee on Food Additives*. Joint FAO/WHO Expert Committee on Food Additives (JECFA). http://www.inchem.org/documents/jecfa/jeceval/jec_297.htm (accessed March 2013).

JECFA. 2007. *Aluminum. Safety Evaluation of Certain Food Additives*. Prepared by the sixty-seventh meeting of the Joint FAO/WHO Expert Committee on Food Additives (JEFCA). (accessed March 2013).

JECFA. 2011. *Safety Evaluation of Certain Food Additives and Contaminants*. WHO Technical Report Series 960. Prepared by the Seventy-third Meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA): Geneva, CH.

Knight Piésold Ltd. 2013. *Harper Creek Project Appendix N: Fish and Aquatic Habitat Baseline* Prepared for Harper Creek Mining Corp. by Knight Piésold Ltd.: Vancouver, BC.

KP. 2014. *Harper Creek Project Water Quality Predictions*. VA101-458/14-3. Prepared for: Harper Creek Mining Corp. by Knight Piésold Ltd.: Vancouver, BC.

Levitt, H. and J. C. Webster. 1991. Effects of Noise and Reverberation on Speech. In *Handbook of Acoustical Measurements and Noise Control, Third Edition*. Ed. C. M. Harris. New York, NY: McGraw-Hill.

Michaud, D. S., S. H. P. Bly, and S. E. Keith. 2008. Using a change in percent highly annoyed with noise as a potential health effect measure for projects under the *Canadian Environmental Assessment Act*. *Canadian Acoustics*, 36 (2): 13-28.

North Thompson Fish and Game Club. 2014. *Personal Communication*. May 6, 2014. Vancouver, BC.

Poirier, S. and L. Brooke. 2000. Inuit Perceptions of Contaminants and Environmental Knowledge in Salluit, Nunavik. *Arctic Anthropology*, 37 (2): 78-91.

Pufall, E. L., A. Q. Jones, S. A. McEwen, C. Lyall, A. S. Peregrine, and V. L. Edge. 2011. Perception of the Importance of Traditional Country Foods to the Physical, Mental, and Spiritual Health of Labrador Inuit. *Arctic* 64 (2): 242-50.

PWC Consulting. 2002. *Health Insider No. 7: Noise Proprietary Questions for Health Canada*. Health Cananda. http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/noise-bruit/insider7/insider7-eng.pdf (accessed February 2013).

Richardson, G. M. 1997. *Compendium of Canadian Human Exposure Factors for Risk Assessment* O'Connor Associates Environmental Inc.: Ottawa, ON.

Sample, B. E., M. S. Aplin, R. A. Efroymson, G. W. Suter II, and C. J. E. Welsh. 1997. *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants*. ORNL/TM-13391. Oak Ridge National Laboratory, US Department of Energy: Oak Ridge, TN.

Sharpe, S. 2013. *Harper Creek Copper-Gold-Silver Project Appendix T: Human Health and Ecological Risk Assessment - Baseline Technical Data Report*. Prepared for Yellowhead Mining Inc. by Sean Sharpe, R.P. Bio, M. Sc.: Smithers, BC.

Simpcw First Nation. 2012. *Traditional Land Use and Ecological Knowledge Study Regarding the Proposed Yellowhead Mining Inc. Harper Creek Mine*. Final Report, Public Version. Prepared by Simpcw First Nation: n.p.

Standards Australia. 2006. *AS2187.2-2006™ Explosives – Storage and Use Part 2: Use of Explosives; (Appendix J)*. Standards Australia: n.p.

Tannenbaum, L. V., M. S. Johnson, and M. Bazar. 2003. Application of the hazard quotient method in remedial decisions: a comparison of human and ecological risk assessments. *Human and Ecological Risk Assessment*, 9 (1): 387-401.

Terra Archaeology. 2012. *Archaeological Impact Assessment: Yellowhead Mining Inc. Proposed Harper Creek Mine near Vavenby, British Columbia*. Submitted to Simpcw Resources Limited Liability Partnership for Yellowhead Mining Inc: Vancouver, BC.

US EPA. 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*. United States Environmental Protection Agency, Office of Noise Abatement and Control. www.nonoise.org/library/levels74/levels74.htm (accessed May 14, 2013).

US EPA. 1997. *Mercury Study Report to Congress. Vol. III: Fate and Transport of Mercury in the Environment*. United States Environmental Protection Agency: Washington, DC.

US EPA. 1999. *Guidelines for Carcinogen Risk Assessment*. Review Draft. NCEA-F-0644, July. United States Environmental Protection Agency: Washington, DC.

US EPA. 2000. Risk Assessment and Fish Consumption Limits. In *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*.Washington, DC: United States Environmental Protection Agency, Office of Science and Technology, Office of Water.

US EPA. 2012. *AIRTrends 1995 Summary: Particulate Matter (PM-10)*. United States Environmental Protection Agency. http://www.epa.gov/airtrends/aqtrnd95/pm10.html (accessed August 2014).

US EPA. 2013. *Integrated Risk Information System (IRIS)*. http://www.epa.gov/IRIS/ (accessed October 2013).

Vavenby Trail Rides. 2014. *Vavenby Trail Rides, trail rides with a difference*. The Shook Ranch. http://www.vavenbytrailrides.ca/index.php (accessed August 2014).

WHO. 1948. *Preamble to the Constitution of the World Health Organization as Adopted by the International Health Conference, New York, 19-22 June, 1946; Signed on 22 July 1946 by the Representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and Entered into Force on 7 April 1948*. World Health Organization: New York, NY.

WHO. 1999. *Guidelines for Community Noise*. A68672. World Health Organization: Geneva, CH.

WHO. 2000. *Air Quality Guidelines for Europe, 2nd Edition*. WHO Regional Publications, European Series, No. 91. World Health Organization Regional Office for Europe: Copenhagen, DK.

WHO. 2013. *IARC: Outdoor air pollution a leading environmental cause of cancer deaths*. WHO press release. October 17, 2013. http://www.iarc.fr/en/media-centre/iarcnews/pdf/pr221_E.pdf (accessed April 2014).

WorkSafe BC. 2014. *Workers Compensation Act - Excerpts and Summaries. Part 7: Noise, Vibration, Radiation and Temperature*. WorkSafe BC. http://www2.worksafebc.com/publications/ohsregulation/Part7.asp (accessed June 2014).

Personal Communications

Schmidt, M. 2014. North Thompson Fish and Game Club, Personal communication: May 6, 2014.

Sharpe, S. 2014. Sean Sharpe and Associates Environmental Consulting Ltd.: Smithers, BC. Personal Communication: May 14, 2014.