18. ASSESSMENT OF HEALTH EFFECTS

18.1 INTRODUCTION

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

The establishment of a mine and associated activities, including facility construction, mine operation, and the transport and management of coal, chemicals, and rejects/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, Project Construction, Operation, Decommissioning and Reclamation, and Post-Closure have the potential to affect human health via environmental media, such as noise levels, air quality, drinking water, and the quality of country foods.

It is recognized that health is 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, access to primary health care, and risk perception, which are assessed separately in Chapters 14, 15, 16, 17, and 20, and are therefore not included here.

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) and associated policies and guidelines administered by WorkSafe BC, and the Health, Safety, and Reclamation Code (BC MEMPR 2008) administered by the 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. In addition to the regulatory framework in place for mine health and safety, the Proponent will develop Occupational Health and Safety Plans prior to Construction.

However, workers from adjacent infrastructure and activities (e.g., oil and gas wells, forestry, pipelines, turbines) will be considered as potential human receptors to be assessed (Health Canada 2010g). In addition, this human health assessment applies to humans who could enter the Project and surrounding areas on an occasional and temporary basis (e.g., campers, hunters).

All chemicals/stressors from anthropogenic or natural sources have the potential to cause toxicological or physical health effects. Three components have to be present in order for a health risk to exist and, therefore, for a human health assessment to be warranted:

1. An inherently toxic chemical has to be released at a sufficiently high concentration to cause toxicological or physical effects;

2. A human receptor has to be present; and
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., must have a source of noise, a receptor for noise, and a pathway from 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 exists, assuming that mitigation strategies are applied successfully.

Baseline water quality is described in Appendix 8-D; however, because the baseline water quality is assessed using aquatic life guidelines, baseline drinking water quality will be described in this chapter (Section 18.5). A baseline country foods assessment was carried out for the Murray River Project and can be found in Appendix 18-A. Baseline air quality and noise are described in Appendices 6-A and 18-B, respectively.

18.2 REGULATORY AND POLICY FRAMEWORK

The inclusion of human health into the environmental assessment (EA) process in Canada has been mandated by the federal government and by the Province of BC under various legislation and policy requirements (Health Canada 1999, 2010g).

Under the *Canadian Environmental Assessment Act* (2012), the definition of an "environmental effect" includes any changes in health or socio-economic conditions that are caused by the project's environmental effects. The Act requires that the environment be protected from significant adverse environmental effects caused by a designated project.

Under BC's *Environmental Assessment Act* (2002), and environmental assessment certificate is required and the proponent may not proceed with the project without an assessment of whether the project has "a significant adverse environmental, economic, social, heritage or health effect".

The province of BC (Environmental Assessment Office) typically relies on Health Canada to assess the adequacy of the human health effects assessment component of the environmental assessment. Health Canada provides guidance on the type of information required to be included in the effects assessment for human health, including noise levels, air quality, drinking water, and country foods quality (Health Canada 2010g).

The assessment of human health effects has been prepared to fulfill of the requirements of the Application Information Requirements (AIR) as approved by the BC Environmental Assessment Office (EAO), the Environmental Impact Statement (EIS) Guidelines as approved by the Canadian Environmental Assessment Agency (CEAA), and the guidance document titled "Useful Information for Environmental Assessments" authored by Health Canada (Health Canada 2010g).

Standards, guidelines, objectives, and/or criteria for air quality, and drinking water quality have been put in place by the provincial and federal governments with the goal to protect human health (Table 18.2-1). For the purpose of the assessment of noise effects on the general public, guidance from Health Canada (2010g) and international guidance documents (Table 18.2-1) were followed.

Table 18.2-1. Acts, Regulations, Standards, Guidelines, and/or Objectives Intended to Protect Human Health

Name	Year	Type	Level of Government	Description
Drinking Water Protection Act	2001	Act	British Columbia	The *Drinking Water Protection Act* covers 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	2003	Regulation	British Columbia	Schedule A of the *Drinking Water Protection Regulation* lists water quality standards for potable water.
Water Quality Guidelines (Criteria) Reports	-	Guidelines	British Columbia	The approved and working water quality guidelines include thresholds of metals and nutrients for drinking water supply and recreational activities.
Guidelines for Canadian Drinking Water Quality	2012	Guidelines	Federal	The Guidelines for Canadian Drinking Water Quality are established by the Federal-Provincial-Territorial Committee on Drinking Water (CDW) 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	2012	Objectives/ Standards	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.
Canadian Ambient Air Quality Standards	2013	Objectives/ Standards	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	1999	Guideline	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 professional trying to protect people from the harmful effects of noise in non-industrial environments.

(continued)

Table 18.2-1. Acts, Regulations, Standards, Guidelines, and/or Objectives Intended to Protect Human Health (completed)

Name	Year	Type	Level of Government	Description
Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety	1974	Guideline	International	This United States Environmental Protection Agency (US EPA) guideline is recognized by Health Canada as an international standard for noise in the context of public health protection, which can be used for assessment of noise effects on human health in environmental assessments.
Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0	2010	Threshold values for risk assessment	Federal	TRVs are defined by Health Canada, based on international toxicological and epidemiological studies, for the assessment of chronic human health risks found at federal contaminated sites in Canada. A TRV is the daily dose of a chemical that is deemed to be tolerable or acceptable to human receptors.

Detailed thresholds and guidelines used to evaluate potential health effects are presented below.

18.2.1 Drinking Water

Provision of services, such as drinking water supply, is regulated in the province of BC. The *Drinking Water Protection Act* (2001) and *Drinking Water Protection Regulation* (BC Reg. 200/2003) are the key legislation supporting the provision of potable drinking water in BC. This legislation applies to all water systems, other than those that supply single family homes 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 18.2-2). Drinking water quality must comply with the BC DWQGs (BC MOE 2006a) under the BC *Drinking Water Protection Act* (2001) and BC Drinking Water Protection Regulation (BC Reg. 200/2003).

Where available, BC DWQGs will be used in the assessment. Although not legally enforceable, the Guidelines for Canadian Drinking Water Quality (referred to throughout this Chapter as the Canadian DWQGs; Health Canada (2012a)) and Guidelines for Canadian Recreational Water Quality (Health Canada 1992, 2012b) may be used as guidelines for parameters where BC DWQGs are not available.

18.2.2 Air Quality

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

Table 18.2-2. Provincial and Federal Drinking Water Quality Guidelines

Parameter	BC Drinking Water Quality Guidelines (mg/L)[1]	Canadian Drinking Water Quality Guidelines (mg/L)[2]
Aluminum[3]	0.2	0.1
Antimony	0.014	0.006
Arsenic	0.025	0.010
Barium	-	1
Beryllium	0.004	-
Boron	5	5
Cadmium	-	0.005
Chromium	-	0.05
Copper	0.5	1
SAD-Cyanide and Thiocyanate (CN)	0.2	0.2
Fluoride	1.5	1.5
Lead	0.05	0.010
Mercury	0.001	0.001
Molybdenum	0.25	-
Nitrate (as N)	10	10
Nitrite (as N)	1	1
Selenium	0.01	0.01
Sulphate (SO_4)	500	-
Thallium	0.002	-
Uranium	-	0.02
Zinc	5	5

[1] *BC Drinking Water Quality Guidelines – approved and working (BC MOE 2013g).*
[2] *Guidelines for Canadian Drinking Water Quality Summary Table (Health Canada 2012a).*
[3] *BC Drinking Water Quality Guideline for aluminum is based on dissolved aluminum concentrations.*

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. CEPA also regulates emission sources that lie beyond provincial authorities such as motor vehicles and fuel, marine vessels, railways, and off-road engines (BC MOE 2013b).

The *Environmental Management Act* (EMA; 2003) and *Waste Discharge Regulation* (WDR; BC Reg. 320/2004) are the most important pieces of legislation for air quality in BC. The EMA provides a flexible authorization framework, increases enforcement options, and uses modern environmental management tools (BC MOE 2013e). The WDR, under the EMA, stipulates that it is applicable to mining and mining activities such as clearing and 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*, and the *Open Burning Smoke Control Regulation*.

Ambient air quality objectives are non-statutory limits that provincial or federal governments place on the level of contaminants in the atmosphere in order to guide decisions to protect human health and the environment. Discharge limits of fugitive dust and air contaminants, as well as ambient air quality objectives (in particular for dustfall), may also be explicitly written into a waste discharge air permit.

The federal and provincial ambient air quality criteria are summarized in Table 18.2-3. The national ambient air quality objectives (NAAQOs) have been the benchmark for Canadian impact assessment of anthropogenic activities on air quality (CCME 1999a). The first NAAQOs developed in the mid-1970s consisted of a three-tiered approach (maximum desirable, acceptable, and tolerable levels). The NAAQOs framework, introduced in the National Air Pollution Surveillance (NAPS) data report for the year 2000 (Environment Canada 2013b), specified two levels developed through extensive scientific assessment:

- a reference level, which is the level above which there are demonstrated effects on human health, and/or the environment; and
- an Air Quality Objective, which reflects a specific level of protection for the general population and environment and also considers aspects of technical feasibility (Environment Canada 2013b).

Table 18.2-3. Federal and Provincial Ambient Air Quality Criteria

		Concentrations (μg/m³)					
		National Ambient Air Quality Objectives[1]			BC Ambient Air Quality Objectives[2]		
Pollutant	Averaging Time	Maximum Desirable	Maximum Acceptable	Maximum Tolerable	Level A / Maximum Acceptable	Level B / Maximum Tolerable	Level C
SO_2	1-hour	450	900	-	450	900	900
	24-hour	150	300	800	160	260	360
	Annual	30	60	-	25	50	80
NO_2	1-hour	-	400	1,000	400	1,000	-
	24-hour	-	200	300	200	300	-
	Annual	60	100	-	60	-	-
CO	1-hour	15,000	35,000		14,300	28,000	35,000
	8-hour	6,000	15,000	20,000	5,500	11,000	14,300
TSP	24-hour	-	120	400	120	200	260
	Annual	60	70	-	60	70	75
PM_{10}	24-hour	-	-	-	-	50	-
$PM_{2.5}$	24-hour	-	27[a]	-	-	25[b]	-
	Annual	-	8.8[a]	-	-	8[c]	-

Notes: (-) dash indicates not applicable
[1] CCME (1999a).
[2] BC MOE (2013a).
[a] Ambient Air Quality Standards for $PM_{2.5}$ applicable in 2020 (Environment Canada 2013a).
[b] Based on annual 98th percentile value.
[c] BC objective of 8 μg/m³ and planning goal of 6 μg/m³ was established in 2009.
Shaded cells indicate the guidelines used in this assessment.

The original objectives have not been formally revised to the new two-level system, which includes a reference level and an objective. In the interim, sulphur dioxide (SO_2), oxides of nitrogen (NO_2), carbon monoxide (CO), and ozone (O_3) are typically compared with the existing desirable and acceptable NAAQOs.

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 2013e). The BC air quality objectives are generally similar to those from NAAQOs; however, some pollutants are only regulated by either the federal or the provincial government.

The Canadian Council of Ministers of the Environment (CCME) developed Canada-Wide Standards (CWS) for $PM_{2.5}$ and O_3 in 2000. Since BC is a member of the CCME, a 24-hour $PM_{2.5}$ CWS of 30 $\mu g/m^3$ (based on the annual 98th percentile averaged over three consecutive years), is being implemented in BC. In 2009, new ambient air quality criteria for $PM_{2.5}$ were developed in BC (BC MOE 2013d). The 24-hour $PM_{2.5}$ objective of 25 $\mu g/m^3$, based on an annual 98th percentile, is more stringent than the CWS for $PM_{2.5}$. BC also established an annual average objective of 8 $\mu g/m^3$ for $PM_{2.5}$ and a planning goal of 6 $\mu g/m^3$ to keep the air clean and the environment healthy.

Regional and municipal governments can also develop bylaws to control emissions such as open burning and vehicle idling. The Peace River Regional District, where the Project is located, has created an anti-idling policy for municipal operations (city and fleet vehicles) and encourages the public to turn off cars if idling will last longer than 10 seconds. The Regional District has also put open-burning bylaws in place.

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. The dustfall objective depends on whether the receiving environment is considered to be sensitive (lower value) or not (higher value). The most conservative available criteria were used in this assessment.

18.2.3 Country Foods

For assessing the potential for contamination of country foods under baseline and Project conditions, Health Canada indicates that the human health risk assessment should "consider adequate baseline data and/or modelling of contaminants of potential concern (COPCs) in country foods prior to any project activities" (Health Canada 2010g). A country foods baseline assessment report was completed to fulfill this requirement (Appendix 18-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; the estimated daily intakes (EDI) of contaminants were compared to the TDIs to determine the level of risk. An equivalent approach will be used to assess the potential for Project-related effects on country food quality as part of the effects assessment.

Recently, the BC MOE completed an update of the selenium water quality guideline, which included tissue concentrations of selenium for the protection of human health; this guideline did not exist when the country foods baseline report was written, so was not included in the report (Appendix 18-A). Therefore, a comparison of baseline fish tissue residues to the selenium tissue guideline is provided in Section 18.5.3.3.

18.2.4 Noise

There is currently no federal or provincial legislation that stipulates noise levels for mine development projects. The Project lies within the Dawson Creek Land and Resource Management Plan (DC LRMP; BC MFLNRO 1999). The DC LRMP does not have any direct restriction or management plan regarding noise in the area (BC MFLNRO 1999).

The US Environmental Protection Agency (US EPA 1974) recommends a background noise level of 55 dBA for areas where people may spend limited amounts of time. The World Health Organization (WHO 1999) has published guidelines on recommended noise levels to minimize sleep disturbance in humans:

- “if negative effects on sleep are to be avoided, the equivalent sound pressure level should not exceed 30 decibels (dBA) indoors for continuous noise”; and
- “for a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{max} more than 10 – 15 times per night.”

Michaud, Bly, and Keith (2008) suggests the calculation of the percent highly annoyed (% HA) metric as a measure of potential health effects from noise. A % HA of equal to or greater than 6.5% is recommended as an indicator of noise-induced human health effects for long-term project noise (Michaud, Bly, and Keith 2008) when noise duration is expected to exceed one year.

The most commonly used noise metrics are L_{AE}, L_{eq}, L_{90}, L_{max}, L_d, L_n, L_{ex}, and L_{dn} and they are defined in Table 18.2-4.

Table 18.2-4. Common Noise Metrics

Noise Matrix	Definition
L_{AE}	Sound exposure level.
L_{eq}	Continuous equivalent sound level over a time period.
L_{90}	Sound level exceeded for 90% of the measurement period.
L_{max}	Maximum A-weighted, fast time constant sound level.
L_d	Daytime (7:00 to 20:00) equivalent sound level.
L_n	Nighttime (20:00 to 7:00) equivalent sound level.
L_{dn}	Day-night equivalent sound level over 24-hour period, with 10 dB penalty added to the nighttime sound level.
L_{ex}*	Maximum long-term noise exposure of workers.

* *L_{ex} criterion from WorkSafe BC (2014) based on Occupational Health and Safety Regulation (BC Reg. 296/97).*

Sound levels are often presented as continuous equivalent sound level over a time period (L_{eq}). The L_{eq} includes all noise from all sources, including anthropogenic sources such as helicopters and aircraft. Therefore, L_{eq} does not typically reflect the natural noise level conditions in the area. An alternative metric is L_{90}, the ninetieth percentile level, or the sound pressure level which is exceeded 90 percent of the time during the measurement period. The L_{90} provides a better indication of the natural noise levels in an area, since discrete events generated by anthropogenic sources are usually excluded from the measurement metric.

18.3 Regional Overview

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), because the focus for this human health chapter follows a human health risk assessment approach. The physical environment is one of several determinants of human health recognized by Health Canada (2004). Political, social, cultural and economic factors are also considered determinants of human health, which are included in Chapters 14, 15, and 19.

18.3.1 Drinking Water

Water quality is an essential component of the ecosystem and is linked to human health directly via drinking 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. Human health can be affected by chemical (e.g., ions, metals) and bacteriological constituents that may be present in untreated, naturally-occurring surface waters.

There are several water licences within the Project RSA, shown in Figure 18.3-1. Licences to use surface water are administered by the Water Stewardship Division of the BC MOE (2013c). 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 or from the LSA. All of the other water licences are for industrial use except the licence for the City of Dawson Creek and this water licence is inside the RSA but not within the LSA.

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 Northern Health Authority provides information on drinking water wells used to supply water systems regulated by the *Drinking Water Protection Act* (Data BC 2014). Within the RSA, the community of Tumbler Ridge, the Wolverine Mine, and the Quintette Mine obtain drinking water from wells (Figure 18.3-2). The Tumbler Ridge water system consists of a deep groundwater well. The town of Tumbler Ridge has a population of about 3,000 people (Tumbler Ridge 2013). The Wolverine Mine site has four shallow groundwater wells. The Quintette Mine has one well but it is unknown if the well is shallow or deep. Water treatment according to the *BC Drinking Water Protection Act* (2001) will ensure the protection of human health and therefore the well water is not included in this assessment. In addition, an artesian well and a number of wells with unknown use designation are located in or near Tumbler Ridge (Government of BC 2013).

Figure 18.3-1
Water Licenses within the Baseline Drinking Water Local and Regional Study Areas

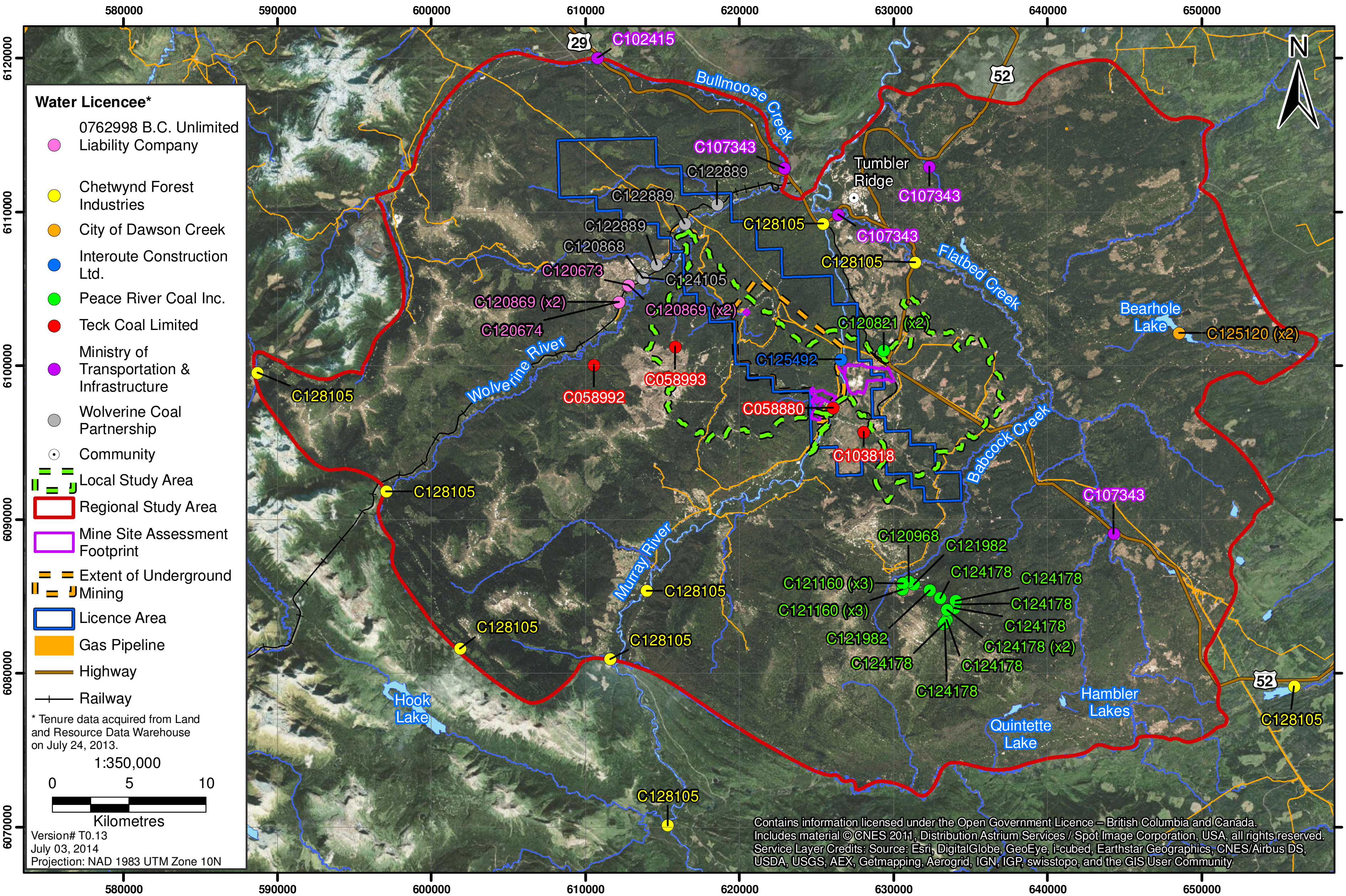
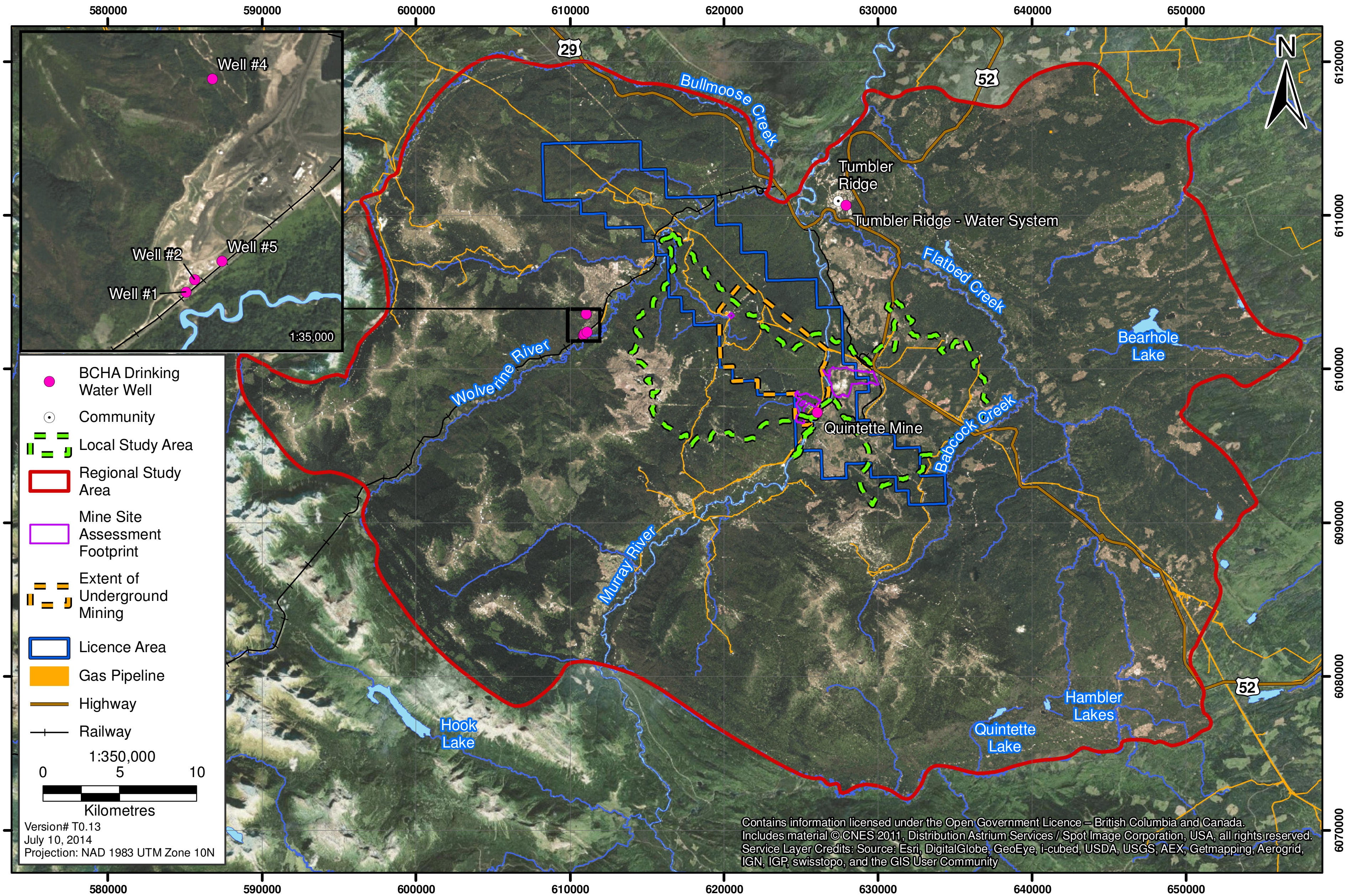


Figure 18.3-2

British Columbia Health Authority Drinking Water Wells within the Baseline Drinking Water Study Areas



18.3.2 Air Quality

Air quality is an important environmental factor in ensuring the conservation of local vegetation, wildlife, and human health values. The Project lies within the Dawson Creek LRMP (BC MFLNRO 1999), and this management plan specifies that air quality must be sustained or enhanced across the planning area, thus emissions require management to meet provincial air quality standards.

Five dustfall stations were established to monitor baseline conditions for the Project, which indicated that baseline dustfall levels were below BC MOE limits. However, some localized dust effects have been noted for other mine sites in the area. Air quality stations that monitor other air contaminants have been established at several locations near the Project, which are described in Section 18.5.3.2. Overall, air quality is fine for most parameters of potential concern (e.g., sulphur dioxide and nitrogen dioxide); however, exceedances of BC objectives for $PM_{2.5}$ and PM_{10} were noted at locations near urbanized areas (e.g., Tumbler Ridge Airport and Industrial Station).

18.3.3 Country Foods

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. 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.

Hunting, trapping, fishing, plant collection, cultural events, and recreational activities are common activities among FNs, residents, and guide/outfitting operators (Chapters 16 and 17). Traditional and current use areas for the Treaty 8 FN communities located closest to the Project apply to: McLeod Indian Band (MLIB), West Moberly Lake First Nations (WMFN), Saulteau First Nations (SFN), Blueberry River First Nations (BRFN), and Horse Lake First Nation (HLFN). Existing highways (highways 29 and 52), and a network of logging roads provide relatively easy access to the region for all FN and non-FN communities in the area.

Hunting, trapping, and fishing remain culturally and economically significant activities for all regional FN communities (PMT SRMP 2006). Moose is the mainstay of the hunting economy, although a variety of other animals (mountain goat, mountain sheep, elk, caribou, smaller mammals, and birds) are also hunted. Berry/plant harvesting was historically, and continues to be, an important activity among FNs in the area (Chapter 17).

The SFN reported the importance of moose and other large mammals such as elk and deer for subsistence harvesting, their way of life, culture, and identity (The Firelight Group 2014). Some SFN members continue to hunt within the Project's footprint and LSA with moose, elk, and grouse the most commonly hunted species but deer, wolf, porcupine, and rabbit are hunted there as well. Bull Trout, Grayling, Rainbow Trout, and Whitefish are also caught within the Project's footprint and LSA and RSA by SFN members (The Firelight Group 2014). Berry picking (i.e., huckleberries, blueberries, cranberries, and raspberries) and medicinal plant (e.g., devil's club, tree bark) collection are also an important subsistence and cultural activities by SFN members that takes place within the Project footprint, the LSA and RSA (The Firelight Group 2014).

FNs located closest to the LSA and included in the First Nations Food, Nutrition and Environment Study (Saulteau and Doig River FN, located in eco-region 2, Chan et al. 2011) have a much higher percentage (90%) of people who eat vegetables and/or fruits from their gardens or community gardens than the total of BC on-reserve FN (58%). On-reserve FN people in eco-region 2 also hunt, fish, and gather traditional foods at a higher percentage (66, 37, 46%, respectively) than the total of BC on-reserve FN (20, 37, and 33%, respectively).

18.3.4 Noise

Noise is generally characterized by human receptors as an unwanted sound. Human perception of the pressure of the sound wave is non-linear: a ten-fold increase in sound pressure is perceived as a doubling of the noise level by the average person. This non-linearity is reflected in the use of the decibel unit (dB), a logarithmic measure of noise level. Noise has intrinsic importance to employees, local residents, and temporary land users, and noise can directly affect the health of humans. Noise may result in psychological and physiological effects in humans, such as irritation, interference with speech comprehension, sleep disturbance, and hearing loss.

Due to the localized and short-lived nature of noise, noise levels are not monitored regionally; however, noise levels were monitored as part of the baseline studies for the Project, which can help define the background noise level in the area. Noise levels monitored within the study area are comparable to baseline levels for rural areas suggested in the Alberta Energy and Utilities Board Directive 038 (Alberta ERCB 2007).

18.4 Historical Activities

Several historic and current human activities are within close proximity to the proposed Project Area. These include mining exploration and production, oil and gas, forestry, tourism/recreation and hunting/trapping.

The Quintette Coal Mine, about 20 km south of Tumbler Ridge, was an open pit mine that operated between 1982 and 2000. The mine consisted of five open pits in three discrete areas: Sheriff (Wolverine and Mesa Pits), Frame (Shikano Pit) and Babcock (Windy and Window Pits). Mine permits for the Wolverine and Mesa Pits were issued in December 1982 and mining commenced from 1983 until 1998 (Wolverine) and 2000 (Mesa). Raw coal was transported via an overland conveyor from the Mesa and Wolverine Pits to the Quintette plant site for processing. The coal processing plant has been under care and maintenance since the end of mining in 2000; the overland conveyor, which previously crossed through a portion of HD Mining's Decline Site, was decommissioned by Teck in 2011. Teck is currently securing the necessary approvals to re-initiate mining in the Babcock area.

The Bullmoose Coal Mine operated from 1983 to 2003 and was the largest open pit coal mine at the time, producing about 3 million tons of metallurgical coal. The 1.7-million-tonne-per-year operation consisted of an open-pit mine, a plant facility in the Bullmoose Creek valley below the mine, and a separate rail loadout facility on the B.C. Rail branchline.

Previous exploration in the area included seismic lines and drilling for oil and gas wells which helped target areas for coal exploration. Twelve cutblock licences exist within the LSA; three of these are held by the proponent. Large portions of the LSA have been recently harvested to remove pine-beetle affected timber.

Subsistence activities, such as trapping, hunting, and fishing are common land uses regionally. The Saulteau First Nations Knowledge and Use Study (The Firelight Group 2014) reports that within the proposed Project Footprint, LSA, and RSA there is extensive use by Saulteau First Nations (SFN) members, which includes hunting, fishing, berry and plant harvesting, camping, and other uses. In addition, Murray River is used as a water route for travel, hunting, and fishing. HD Mining has engaged the WMFN, SFN, and MLIB to obtain information regarding traditional knowledge/traditional use (TK/TU) studies, but results for the MLIB and WMFN were not available at the time of writing the EA assessment. HD Mining also met with BRFN and HLFN and provided information packages about the Project and solicited information regarding their interests that could potentially be impacted by the Project. Responses by BRFN and HLFN were not available at the time of writing the EA assessment.

Three trapping tenures and four guide-outfitting tenures overlap the RSA. Multiple recreation tenures, as well as temporary and permanent residences exist within the Project area. The nearest trapline cabin is 1.7 km from the Project on the west bank of Murray River, the nearest campground is 9.5 km north from the Project (near Tumbler Ridge), the nearest hunt camp is 26 km west from the Project, and the nearest residential area (Tumbler Ridge) is 12.4 km north from the Project. These locations have been considered as receptor sites in the human health assessment, because land users (i.e., hunters, campers) may be exposed for several days at hunting cabins or camp grounds, and families and sensitive persons (i.e., children, elderly) reside in Tumbler Ridge. The Health Services Center in the south end of Tumbler Ridge was chosen as a representative receptor location for sensitive individuals.

There are multiple previously recorded archaeological sites (pre-contact lithic scatters) within 5 km of the proposed Project infrastructure. However, these sites were not included in the human health assessment because people do not live there currently.

The Project is located near two provincial parks and protected areas. Bearhole Lake Provincial Park and Protected Area is located approximately 17 km east of the Project, and Monkman Provincial Park is located approximately 27 km south of the Project.

All of the above historical or current activities 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.

18.5 BASELINE STUDIES

Human health is affected by several physico-chemical environmental components, namely by the quality of drinking water, the quality of air that people breath, the quality of foods (especially country foods for FNs people) and noise. Therefore, baseline study results for these four components were included to describe the environmental baseline conditions that can affect baseline human health.

Table 18.5-1 provides an overview of the type of baseline studies conducted for the Project and the years that these studies spanned.

Table 18.5-1. Summary of Baseline Studies for the Project

Subject Area	Field Baseline Studies	Years of Available Data
Atmospheric Environment	Air quality	2011 Air Quality Baseline Report
	Noise	2012 Noise
Freshwater Environment	Water Quality	2010-2014 Water Quality and Aquatic Resources
Human Environment	Country Foods	2012 Country Foods Baseline Report

18.5.1 Data Sources

18.5.1.1 Drinking Water Quality

Drinking water quality was not specifically the subject of a baseline report. However, following the Application Information Requirements (AIR; BC EAO 2014) and EIS Guidelines (CEAA 2013a), a comprehensive surface water quality baseline monitoring program was conducted between 2010 and 2014 (Section 8.3, Appendix 8-D). The objective of the water quality baseline program was to collect water quality data from selected stream and wetland sites in the Project area and assess baseline water quality using aquatic life guidelines. Water chemistry data from the baseline monitoring program were compiled in Appendix 8-D of Chapter 8 and these data were then used to assess the potential for human health risk from the drinking of surface water.

18.5.1.2 Air Quality

The existing baseline or background air quality data represent ambient air concentrations prior to the Project commencement due to emissions from both natural and anthropogenic sources. Dustfall monitoring has been conducted for a number of mine sites in north east BC including Hermann Mine, Wolverine Mine, Trend Small Mine and Dillon Mine (Pomeroy 2007) and Roman Mine (PRCI 2010) and these monitoring data have been included in the baseline.

Project-specific baseline air quality monitoring is restricted to passive dustfall monitors due to the lack of power in remote areas for samplers of other common air contaminants (e.g., CACs). Therefore, the existing air quality across the RSA has been determined from available monitoring data from representative stations and a literature review of other air quality studies in the area and is discussed in detail in Section 6.1 (Air Quality and Greenhouse Gases Chapter) and in Appendix 6-A. PM_{10} (particulate matter up to 10 micrometers in size) was also monitored at the Tumbler Ridge Airport (2006-2008) and the Tumbler Ridge Industrial Park (2008). $PM_{2.5}$ was monitored at Tumbler Ridge Airport (2006-2008) and Beaverlodge (2006-2012), while NO_2 and SO_2 were monitored only at Beaverlodge (2006-2012).

18.5.1.3 Country Foods Quality

The 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 study area. The country foods baseline methodology and approach followed the AIR (BC EAO 2014), EIS Guidelines (CEAA 2013a), and Health Canada guidance (Health Canada 2010b, 2010d, 2010a, 2010g). 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 18-A). The concentrations of COPCs in selected country foods were measured or modelled and a human health risk assessment was completed to determine the potential for human health effects from consumption of selected country food items under baseline conditions.

The country foods assessment relies on a number of data sources which are located in Chapter 8 (Surface Water and Aquatic Resources), Chapter 9 (Fish and Fish Habitat), Chapter 11 (Terrestrial Ecology), Chapter 13 (Wildlife), Chapter 15 (Social), and Chapter 16 (Land Use). Statistical summaries of the data sets are presented in the 2012 Country Foods Baseline Report (Appendix 18-A).

Human receptor consumption characteristics (country food intake amounts, frequencies and country food species) for the Treaty 8 FNs 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). Efforts were made to contact all FN study communities to verify the information from the Chan et al. (2011) report (Chapter 2, Appendix 2-D). HD Mining has engaged FNs to obtain traditional knowledge/traditional use (TK/TU) information, but with the exception of the SFN, results were not available at the time of writing the baseline assessment. Recently, a report on SFN traditional and current land use has become available (The Firelight Group 2014); however the SFN report does not contain quantitative consumption characteristics (e.g., portion sizes and consumption frequencies of country foods), thus data from the study by Chan et al. (2011) continue to be used.

18.5.1.4 Noise

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. A baseline noise monitoring programme was conducted by Rescan during 2012 and 2013. Full details of the noise baseline are included in the 2012 Noise baseline report (Appendix 18-B). No additional data sources were used. The noise baseline study followed methods as described in the AIR (BC EAO 2014).

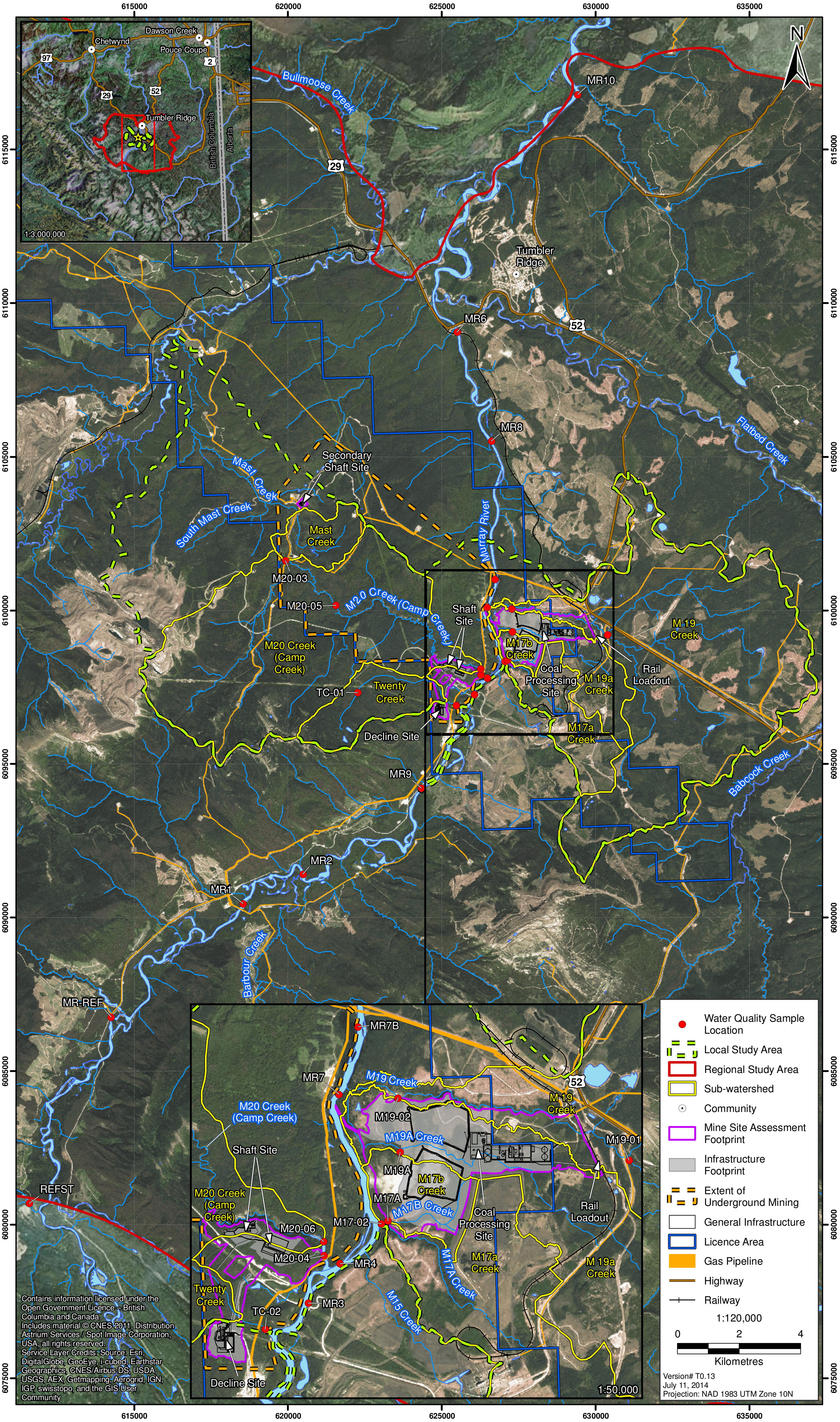
18.5.2 Methods

18.5.2.1 Drinking Water Quality

Surface water was collected from a total of 23 stream/river sites, 18 of which are located inside the LSA, between 2010 and 2014 (Appendix 8-D; Rescan 2013a). The water quality sampling sites inside the LSA were situated in areas potentially affected by the proposed Project (Figure 18.5-1). This includes the Murray River, M17, M19, M20 creeks, and Twenty Creek. The water samples were analysed for metals, nutrients, major anions, and benzo(a)pyrene (three samples only), as described in Appendix 8-C and 8-D. For the purposes of characterizing the drinking water quality baseline conditions, only sites that were included as nodes in the water quality model are discussed here. A full summary of all water quality data, as it relates to drinking water quality is provided in Chapter 8, Section 8.5.

Figure 18.5-1

Baseline Surface Water Quality Sampling Locations within the Drinking Water Local Study Area



Summary statistics (median and 95th percentile) of 481 samples collected from inside the LSA were compared to guidelines. The quality of surface water in the LSA was compared to British Columbia (BC MOE 2013g) and Canadian drinking water quality guidelines (DWQGs; Health Canada 2012a). In cases where BC DWQGs were absent for a parameter, the Canadian DWQGs were used if available.

The Canadian DWQGs (Health Canada 2012a) 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.

18.5.2.2 Air Quality

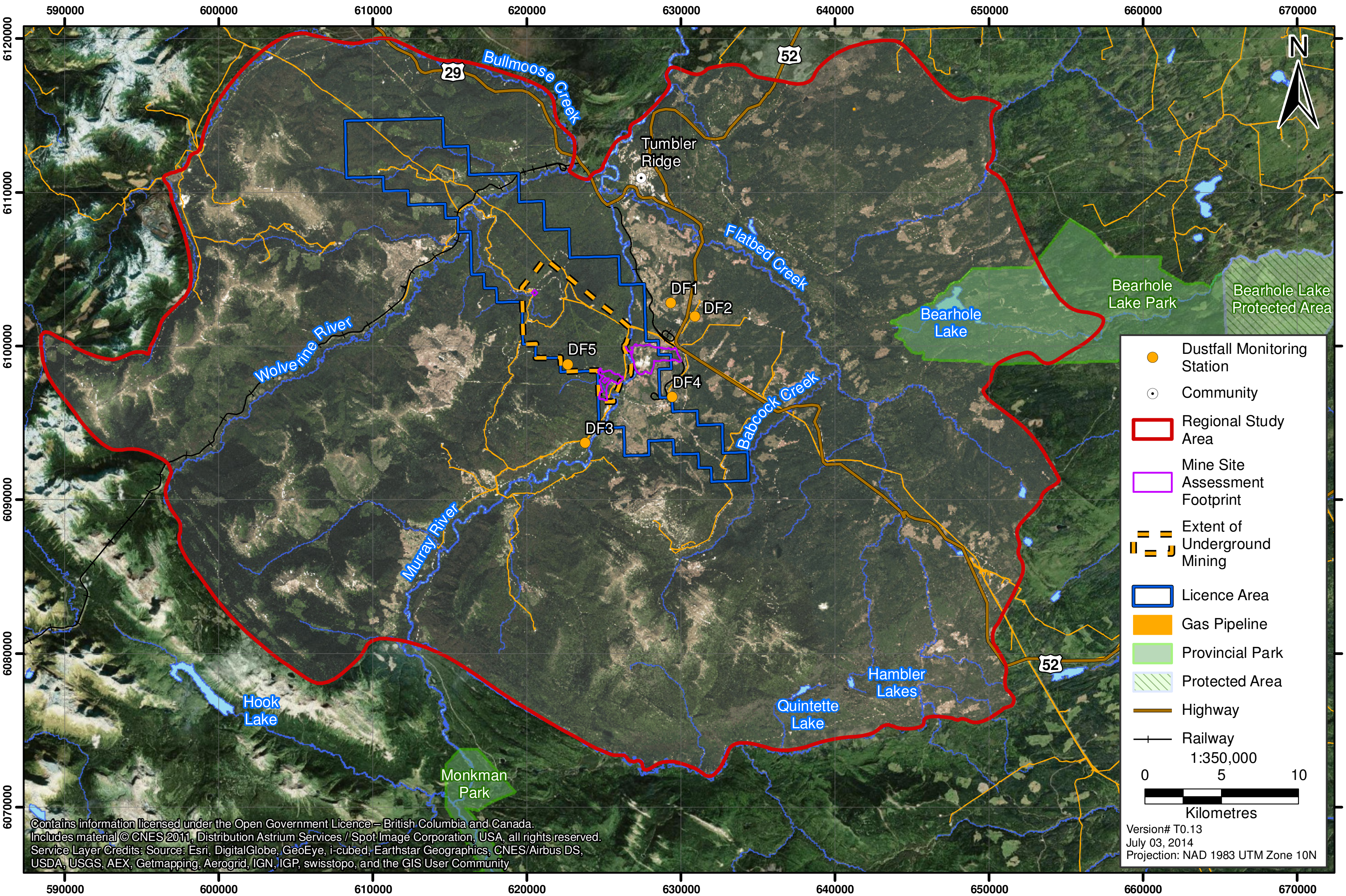
The study area for the air quality baseline evolved between the 2010 baseline program and the 2011 baseline program as new information about the Project, Project footprint, and the Mine Surface Development Area (MSDA) became available. The final LSA was refined to 77.5 km^2 and a RSA of 2277 km^2, as illustrated in the 2011 Air Quality Baseline Study report (Appendix 6-A).

Dustfall monitoring was conducted as part of the Project baseline program (Chapter 6, Appendix 6-A), and was developed in accordance with the sampling method ASTM D 1739-98 (reapproved 2010; ASTM 2010). Five locations were selected for dustfall monitoring for baseline conditions, including a "control" dustfall monitoring station, outside the boundaries of the footprint for the proposed coal mine (Figure 18.5-2). Dust fall monitoring containers were exposed to the air for 30 days (+/- 3 days) and the contents analyzed for total particulate, soluble particulate, insoluble particulate, sulphate, nitrate, ammonia (NH_3 and NH^{4+}, and chloride anions (Cl^-), total metals and base cations (Mg^+, Ca^+, K^+) by ALS Environmental Laboratory in Burnaby, BC (Chapter 6, Appendix 6-A). Project-specific baseline air quality monitoring is restricted to passive dustfall monitors due to the lack of power in remote areas for samplers of other common air contaminants (i.e., CACs). In addition to dustfall baseline data, literature data were compiled by the air quality specialist from various sources (Section 18.5.1). All background data are provided in Chapter 6 (Air Quality and Greenhouse Gasses), Section 6.5.1.

18.5.2.3 Country Foods

The LSA and RSA for the drinking water and country foods baselines were the same because of the strong linkage between the quality of water and the quality of country foods, especially aquatic country foods. The LSA boundaries for the 2012 Country Foods Baseline Report were based on the Project footprint and information available in 2012 and encompassed an area of 77.5 km^2. The RSA boundary was based on the wildlife habitat suitability study and encompassed 2277 km^2. Figure 1-2 in the Country Foods Baseline report (Appendix 18-A) illustrates the baseline LSA and RSA boundaries.

Figure 18.5-2
Dustfall Monitoring Locations



Detailed methodology for the country foods baseline study is provided in Appendix 18-A. The approach for the country foods baseline study was based on Health Canada's guidelines for assessing food issues in environmental impact assessments (Health Canada 2010a, 2010g). As such, this study was divided into the following five stages:

1. Problem Formulation: The conceptual model for conducting the country foods study was developed in the problem formulation stage. This stage identified the COPCs and human receptor characteristics.
2. Exposure Assessment: The measured or predicted metal concentrations in country foods were integrated with human consumption characteristics to calculate the estimated daily intake (EDI) of COPCs.
3. Toxicity Assessment: The Toxicity Reference Values (TRVs; 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 TRVs to produce quantitative risk estimates (exposure ratios, ERs). In addition, the Recommended Maximum Weekly Intake (RMWI) of each country food was calculated.
5. Uncertainty Analysis and Data Gaps: The assumptions made throughout the study and their effects on the conclusions were evaluated.

Environmental quality data (metal chemistry data) were compiled from the baseline monitoring programs for water, sediment, soil, and vegetation (Appendix 18-A). Specific metals were selected as COPCs if they met at least one of the following four screening criteria:

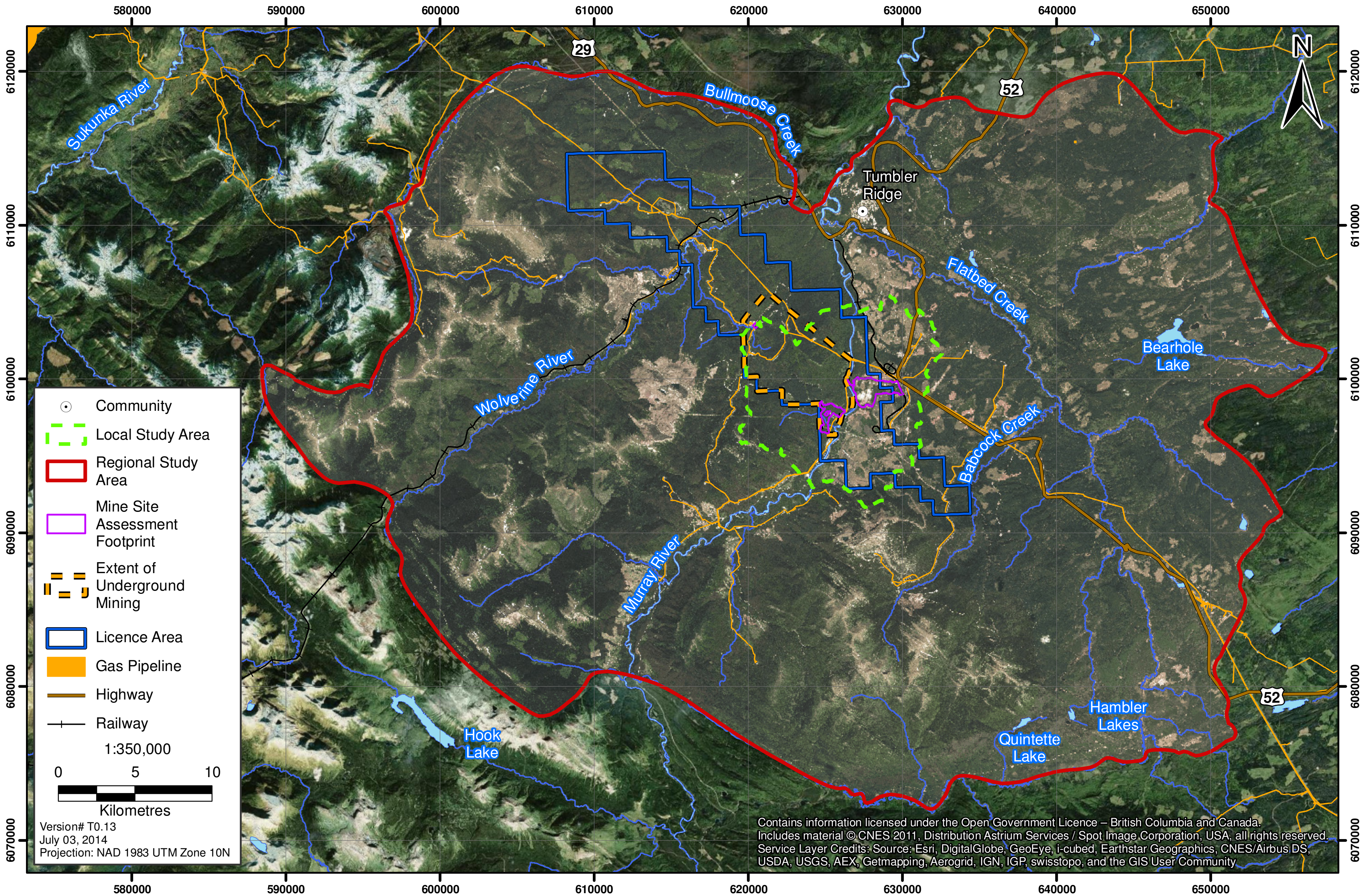
1. The 95th percentile metal concentration in soil samples exceeded its CCME soil quality guideline for agricultural land (CCME 2012b).
2. The 95th percentile total metal concentration in surface water samples exceeded its BC (maximum water criteria) or CCME water quality guideline for the protection of aquatic life, whichever guideline was lower (BC MOE 2006a; CCME 2012c).
3. The 95th percentile metal concentration in sediment samples exceeded its CCME sediment quality guideline for the protection of aquatic life (CCME 2012a) or CCME and BC interim sediment quality guidelines (ISQGs). If ISQGs were not available, screening level concentrations (SLC) were used (BC MOE 2006b).
4. The metal has a potential to bioaccumulate in organisms or biomagnify in food webs, such that there could be significant transfer of the metal from soil to plants and subsequently into higher trophic levels.

The country food users that were included in the assessment are adult and toddler FN people of Treaty 8 FNs. Existing highways (highways 29 and 52) and a network of logging roads provide relatively easy access to the LSA for all FN and non-FN communities in the area (Figure 18.5-3). To provide a conservative estimate of human exposure to COPCs from country foods, the baseline report assumed that 100% of the consumed country foods were collected or hunted from within the LSA.

Figure 18.5-3

Country Foods Baseline Local and Regional Study Areas

ERM



Both 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 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.

18.5.2.4 Noise

Noise sampling was conducted as a part of noise baseline program (Appendix 18-B). Four noise monitoring stations were set up at three sites across the RSA and were surveyed during two periods; July 23 to 26, 2012 (summer) and January 22 to 24, 2013 (winter; Figure 18.5-4). An additional monitoring station was included in the January 2013 (winter) survey. Each monitor was set up to record noise levels for a 24-hour period. Monitoring locations were selected to characterize the range of baseline conditions in the region, based on their proximity to proposed infrastructure and mine areas where future mining activities are expected. Exact locations are provided in Appendix 18-B.

Baseline noise samples were collected using Brüel & Kjær Model 2250 sound level meters capable of logging data. These instruments have operating ranges from 16.7 to 140 dBA (at 1 kHz pure tone signal) that captures low sound levels, which are typical for undisturbed wilderness areas, as well as high sound levels. Each instrument's microphone was protected by a wind screen/weather shield and bird spikes. Other than the ground, all surfaces or obstacles were at least 3 m away from the stations. A weather resistant case protected the meter and battery pack and provided a stable base for each kit. The average, minimum and maximum peak sound levels were measured using the "A" standardized frequency rating (dBA), designed to match the frequency response of the human ear.

Since human sound detection ability is frequency dependent, the sound pressure is commonly weighted by frequency to model human perception. The "A" weighting is the most common; A-weighted noise levels are given in units of "dBA". A change in noise level of 3 dBA is barely noticeable, while a 10 dBA change is perceived as a doubling of the noise level.

Noise levels will vary over time and they are characterized by the equivalent continuous sound level (L_{eq}). This is the dBA level of a constant sound pressure containing the same energy as the time varying noise. It is usually given for a specific time interval, typically 1-hour or 24-hours, using the 0.1 second monitoring data. L_{90} is the ninetieth percentile level (the sound pressure level that is exceeded 90 percent of the time during the measurement period). For example, L_{90} = 20 dBA means that the sound pressure level exceeded 20 dBA during 90% of the measurement period. L_{90} is usually regarded as the residual level or the background noise level without discrete and louder events (e.g., helicopters, fixed wing aircraft). L_{max} is the maximum value recorded during an hourly period, using the 0.1 second monitoring data.

Each noise metric and its relevance as a human health indicator is described in detail in Appendix 18-C. Maximum long-term noise exposure limits (85 dBA; WorkSafe BC 2014) for employees working at adjacent Projects were included in Table 18.5-2 since although these workers are not employed by the Project, they are covered under *Occupational Health and Safety Regulations* (BC Reg. 296/97).

Table 18.5-2. Project Noise Guidelines

Project Metric	Description	Limiting Criteria
L_d	Daytime continuous noise level for assessing speech interference	55 dBA [b]
L_n	Nighttime continuous noise level for assessing sleep disturbance outdoors	30 dBA [b, c]
	Nighttime continuous noise level for assessing sleep disturbance indoors [a]	45 dBA [b, c]
L_{dn}	Project noise mitigation required due to excessive annoyance	75 dBA [d]
Δ % HA	Increase in % HA metric before and after Project initiation	6.5% [d, e]
L_{max}	Maximum sound level not to be exceeded more than 10-15 times per night for assessing sleep disturbance	60 dBA [c]
L_{ex}	Maximum long-term exposure level for workers at adjacent projects	85 dBA [f]

Notes:
L_d = daytime (7:00 to 20:00) equivalent sound level
L_n = nighttime (20:00 to 7:00) equivalent sound level
L_{dn} = day-night equivalent sound level over 24-hour period, with 10 dB penalty added to the nighttime sound level
Δ % HA = increase in percent highly annoyed metric before and after Project initiation
L_{max} = maximum A-weighted, fast time constant sound level
dBA = A-weighted decibel
[a] Assumes that people sleeping indoors might have windows open resulting in 15 dB of sound isolation. This indoor reduction was not applied for day time speech interference since people are not restricted to indoors.
[b] US EPA (1974)
[c] WHO (1999)
[d] Health Canada (2010g)
[e] Michaud, Bly, and Keith (2008)
[f] WorkSafe BC (2014) based on Occupational Health and Safety Regulation (BC Reg. 296/97).

18.5.3 Characterization of Human Health Baseline Condition

18.5.3.1 Drinking Water Quality

Water quality is an essential component of the ecosystem, and is linked directly to human health through the intake of drinking water from surface sources and indirectly through food web effects, including vegetation, fish, and wildlife on country foods.

Table 18.5-3 provides the statistical summary of baseline concentration of metals in surface waters between 2010 and 2014 for the parameters with DWQGs from sites that were included in the water quality model as nodes (M20-04, M17-02, M19A, M19-02, and MR7). The baseline assessment relies on existing health-based drinking water guidelines and assumes that land users (FN and non-FN hunters, trappers, recreationists) may drink surface water from streams anywhere inside the LSA, which may be treated or not treated for chemical contaminants (i.e., metals), dependent on the preferred practice of the land user.

Figure 18.5-4

Noise Monitoring Locations

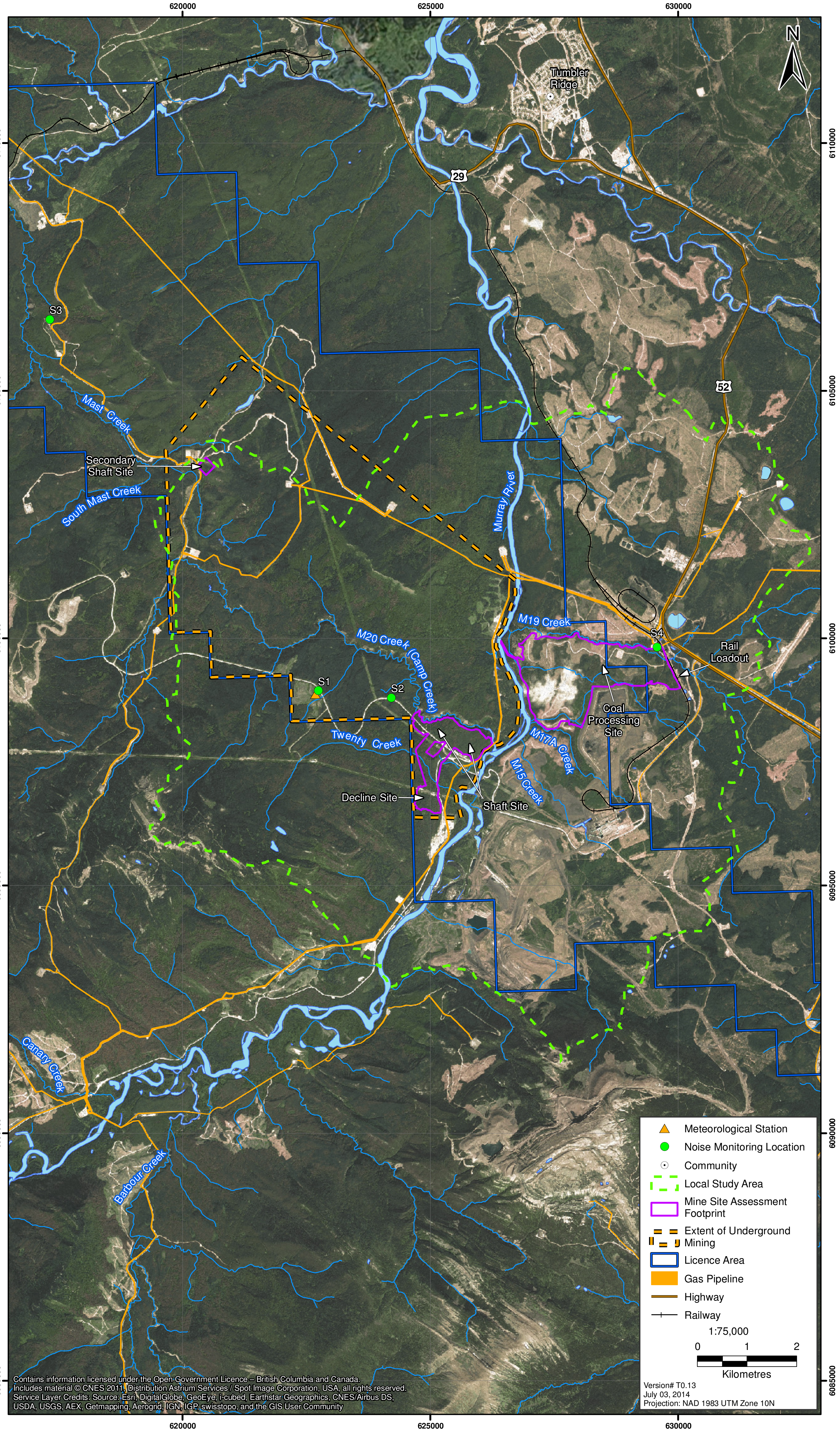


Table 18.5-3. Comparison of Baseline Surface Water Quality to Canadian and British Columbian Drinking Water Guidelines in the Local Study Area (2010 to 2014)

Parameter	pH				Turbidity (NTU)		Chloride (Cl)		Fluoride (F)		Sulphate (SO_4)				Nitrate (as N)		Nitrite (as N)	
Jurisdiction	Health Canada				Health Canada		Health Canada = BC		Health Canada = BC		Health Canada = BC				Health Canada		Health Canada = BC	
Guideline	8.5				0.1		250		1.5		500				10		1	
Stat	Median	95th Percentile	Factor Exceedance	Percent Exceedance	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Factor Exceedance	Percent Exceedance	Median	95th Percentile	Median	95th Percentile
Shaft/Decline Sites																		
M20-04	8.3	8.5	1.0	4%	43.5	661	1.0	2.0	0.1	0.1	45.7	62.1	-	0%	0.06	0.1	0.001	0.001
Coal Processing Plant Site																		
M17-02	8.4	8.5	1.0	5%	5.4	43.7	3.2	17.4	0.1	0.3	131	286	-	0%	0.06	0.3	0.003	0.005
M19A	8.4	8.5	-	0%	0.9	5.9	2.5	2.7	0.1	0.2	216	360	-	0%	0.03	0.1	0.005	0.005
M19-02	8.2	8.3	-	0%	0.8	6.0	2.5	9.7	0.08	0.09	8.4	13.3	1.8	5%	0.09	0.2	0.001	0.001
Receiving Environment																		
MR7	8.2	8.3	-	0%	7.5	68.7	0.8	1.9	0.04	0.06	11.3	30.2	-	0%	0.06	0.1	0.001	0.001

Parameter	Cyanide, Total		Cyanide, WAD		Total Antimony (Sb)		Total Arsenic (As)		Total Barium (Ba)		Total Boron (B)		Total Cadmium (Cd)		Total Chromium (Cr)	
Jurisdiction	Health Canada		BC		Health Canada		Health Canada		Health Canada		Health Canada = BC		Health Canada		Health Canada	
Guideline	0.2		0.2		0.006		0.01		1		5		0.005		0.05	
Stat	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile
Shaft/Decline Sites																
M20-04	0.001	0.009	0.001	0.001	0.0002	0.0005	0.0005	0.006	0.2	0.5	0.02	0.02	0.00006	0.0008	0.002	0.02
Coal Processing Plant Site																
M17-02	0.001	0.001	0.001	0.001	0.0002	0.0002	0.0003	0.0008	0.1	0.1	0.02	0.02	0.00003	0.00008	0.0004	0.002
M19A	0.001	0.001	0.001	0.001	0.0001	0.0001	0.0003	0.0004	0.1	0.2	0.01	0.02	0.00001	0.00003	0.0002	0.0004
M19-02	0.001	0.001	0.001	0.001	0.0001	0.0001	0.0002	0.0004	0.1	0.2	0.01	0.01	0.00001	0.00002	0.0001	0.0004
Receiving Environment																
MR7	0.002	0.005	0.001	0.001	0.0001	0.0001	0.0002	0.001	0.1	0.1	0.01	0.02	0.00002	0.00013	0.0005	0.003

Parameter	Total Lead (Pb)				Total Mercury (Hg)		Total Molybdenum (Mo)		Total Selenium (Se)		Total Uranium (U)		Dissolved Aluminum (Al)			
Jurisdiction	Health Canada				Health Canada = BC		BC		Health Canada = BC		Health Canada		BC			
Guideline	0.01				0.001		0.25		0.01		0.02		0.2			
Stat	Median	95th Percentile	Factor Exceedance	Percent Exceedance	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Median	95th Percentile	Factor Exceedance	Percent Exceedance
Shaft/Decline Sites																
M20-04	0.0006	0.01	1.1	6%	0.000005	0.00007	0.0007	0.001	0.001	0.003	0.0006	0.001	0.02	0.2	1.3	4%
Coal Processing Plant Site																
M17-02	0.0001	0.001	-	0%	0.000005	0.000005	0.001	0.001	0.001	0.003	0.002	0.004	0.002	0.01	-	0%
M19A	0.00003	0.0002	-	0%	0.000005	0.000005	0.0003	0.0004	0.0004	0.0007	0.001	0.002	0.002	0.00	-	0%
M19-02	0.00003	0.0001	-	0%	0.000005	0.000005	0.0003	0.0003	0.0002	0.0003	0.0002	0.0004	0.003	0.01	-	0%
Receiving Environment																
MR7	0.0001	0.002	-	0%	0.000005	0.000005	0.0007	0.0009	0.0002	0.0004	0.0003	0.0004	0.007	0.05	-	0%

Notes:

Values represent mg/L unless otherwise noted.

Values below the detection limit were replaced with half the detection limit for calculations.

Only surface water quality sites that were included in the water quality model as nodes are shown.

The factor exceedance and percent exceedance are only shown for parameters that exceeded guidelines.

Health Canada = BC: indicates the Health Canada and BC drinking water quality guidelines are equivalent.

Baseline water quality exceeded the drinking water quality guidelines for three parameters: pH, lead, and dissolved aluminum (Table 18.5-3). The pH guideline was exceeded at two sites (M20-04 and M17-02) by 4% and 5%, respectively. The lead guideline was exceeded at one site (M20-04) by 6%. The dissolved aluminum guideline was exceeded at one site (M20-04) by 4%. Human health is not likely to be negatively affected by baseline drinking water quality at these two sites (M20-04 and M17-02) since the exceedances are very small (4% to 6%), the exceedances are only periodic, there are no water licenses for these water bodies, there are no known permanent drinking water users of these potential surface water sources. Drinking water consumption amounts and frequency of consumption by transient potential users (such as hunters, trappers, hikers, etc.) is not known, and it is possible that users may bring water with them from other sources outside of the LSA, particularly on day trips. Since the DWQGs are based on frequent and chronic consumption of drinking water, using the DWQGs for occasional consumption of surface water is very conservative. The marginal baseline exceedance of Health Canada and BC DWQGs for pH, lead, and dissolved aluminum within M20-04 and M17-02 combined with low consumption frequency of surface water by potential users is unlikely to result in human health effects due to drinking water. In addition, Health Canada recommends that water collected from surface waterbodies always be treated before it is used for drinking water (Health Canada 2008).

18.5.3.2 Air Quality

All background data for dustfall are provided in Appendix 6-A, but a summary of the data is provided here. All collected dustfall samples from five locations at the Project are below the lower BC MOE limit of 1.7 $mg/dm^2/day$. Dustfall collected during May and June is significantly higher than other 30 day periods. This higher period in dustfall may have occurred because snow cover had melted but vegetation had not yet grown to prevent resuspension of dust by the wind.

Dustfall monitoring from other mine sites in the area show that peak dustfall rates may exceed the BC MOE limits in areas close to the sources. However, these studies show that dust levels fall rapidly with distance from the project boundaries to below guideline levels such that background levels are acceptable.

Table 18.5-4 shows that there were no monitored exceedences of BC's PM_{10} objective at the Tumbler Ridge Airport station in 2006 to 2008 and only one potential exceedance at the Tumbler Ridge Industrial station in 2008, which cannot be confirmed because raw monitoring data were not available. The objective applies to the 98th percentile of 24-hour average concentrations which will be lower than the maximum 24-hour average concentration presented in Table 18.5-4.

Table 18.5-5 shows that there are exceeedences of the 24-hour and annual objectives for $PM_{2.5}$ in 2010 and 2012 at the Beaverlodge monitoring station and potential exceedences at the Tumbler Ridge Airport and Tumbler Ridge Industrial stations in 2008. Both monitoring stations are located in more urbanised areas than the Project site and therefore $PM_{2.5}$ concentrations would likely be lower across the Project site.

Table 18.5-4. Monitored PM_{10} concentrations (µg/m^3), Tumbler Ridge Airport (2006-2008) and Tumbler Ridge Industrial Park (2008)

	Maximum 24-hour Average	
Year	Tumbler Ridge Airport	Tumbler Ridge Industrial Park
Relevant objective	*50*	*50*
2006[a]	21	-
2007	39	-
2008	29	63[b]

[a] Based on four months of data (September to December).
[b] Based on four months of data (August to November).

Table 18.5-5. Monitored $PM_{2.5}$ concentrations (µg/m^3), Tumbler Ridge Airport (2006-2008) and Beaverlodge (2006-2012)

	Tumbler Ridge Airport	Tumbler Ridge Industrial Park	Beaverlodge		
Year	Maximum 24-hour Average [a]	Maximum 24-hour Average [a]	Maximum 24-hour Average [a]	98th Percentile of 24-hour Averages	Annual Average
Relevant objective	-	-	-	*25[b], 30[c]*	*8*
2006	21[d]	-	66.8	13	3.9
2007	24	-	19.2	10	3
2008	59	32	16.5	10.3	3.1
2009	-	-	35	16.5	5.2
2010	-	-	53	27.9	10
2011	-	-	84.8	19.9	6.7
2012	-	-	35.8	25.6	8.3

[a] The $PM_{2.5}$ objective is based on the 98th percentile of 24-hour averages.
[b] Canada-wide Standard.
[c] BC Air Quality Objective.
[d] Based on two months of available data.

Samples from the PM monitor located at the Tumbler Ridge Airport since 2006 were used as baseline concentrations of PM_{10} and $PM_{2.5}$ with the 98th percentile of samples used as the 24-hour baseline concentration and the average of samples used as the annual baseline concentration. Baseline concentrations of TSP were determined from a typical ratio from PM_{10} using the AP-42 aerodynamic particle size multiplier for aggregate handling Appendix 6-B, Appendix A, Conceptual Model Plan). These background concentrations will be added to the predicted Project emissions for the effects assessment.

Monitored NO_2 and SO_2 at the Beaverlodge station for 2006 to 2012 are presented in Tables 18.5-6 and 18.5-7, respectively. Tables 18.5-6 and 18.5-7 show that monitored NO_2 and SO_2 concentrations are well below the most stringent objectives.

Table 18.5-6. Monitored NO_2 concentrations (μg/m^3), Beaverlodge (2006-2012)

Year	Maximum 1-hour Average	Maximum 24-hour Average	Annual Average
Relevant objective	*400*[a]	*200*[a]	*60*[a]
2006	72.9	43.6	8.6
2007	63.9	38.0	8.0
2008	60.2	45.3	8.0
2009	93.8	64.1	8.8
2010	67.5	46.2	8.9
2011	59.4	39.6	5.8
2012	75.8	40.4	6.8

[a] *Most stringent objective presented.*

Table 18.5-7. Monitored SO_2 concentrations (μg/m^3), Beaverlodge (2006-2012)

Year	Maximum 1-hour Average	Maximum 24-hour Average	Annual Average
Relevant objective	*450*[a]	*150*[a]	*25*[a]
2006	57.7	9.2	1.6
2007	141.5	18.2	1.5
2008	88.6	7.2	1.2
2009	45.2	13.6	1.0
2010	31.1	5.3	1.1
2011	95.8	14.0	0.9
2012	19.2	6.6	0.8

[a] *Most stringent objective presented.*

Due to the difficulty in determining background concentrations of SO_2 and NO_2 in the Project LSA and RSA using data from distant sites (Section 18.5.1), baseline concentrations were assumed to be zero based on the recommendation by the BC Ministry of Environment (BC MOE; Appendix 6-B, Appendix A, Conceptual Model Plan). BC MOE also recommended baseline concentrations of CO be equivalent to 200 ppb (232 µg/m^3; Appendix 6-B, Appendix A, Conceptual Model Plan).

18.5.3.3 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, grouse, Bull Trout, Eastern Brook Trout, Mountain Whitefish, highbush cranberry, and currants. For further details on the methodology used for selection of the country foods included in the assessment refer to Section 4.2 of the Country Foods Baseline Report (Appendix 18-A).

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

Some chemicals that may be associated with Project development (i.e., petroleum hydrocarbons) were considered for evaluation in the country foods baseline assessment (Appendix 18-A). Polycyclic aromatic hydrocarbons (PAHs) were analyzed in a subset of water and sediment samples inside the LSA. Water quality data showed that naphthalene was above detection limit (0.000043 mg/L) in one out of a total of three samples taken in June, August, and October of 2010, but was below BC and CCME freshwater quality guidelines (Rescan 2013a). Analysis of sediment samples showed PAH concentrations above detection limit and above guidelines for several PAHs. Hydrocarbons that are associated with coal, although a significant source of PAHs in sediments, are not toxic to aquatic life since they are often not bioavailable (Chapman et al. 1996; Talley et al. 2002; Achten et al. 2011). This is in contrast to PAHs from other sources such as oil, which are bioavailable and could result in adverse effects to the exposed biota (Chapman et al. 1996).

A site-specific study conducted at Pine River and its tributaries including Murray River (its largest tributary) showed that "coal was a major contributor of PAHs to the Pine River watershed" and that benthic invertebrates were not affected by the PAHs from the coal (Pennart et al. 2004). In the country foods baseline assessment (Appendix 18-A), PAH measurements in the freshwater were below the detection limit and elevated PAH levels were only detected in the sediments. As shown in the study by Pennart et al. (2004), the majority of these PAHs in sediments are tightly bound to coal particles. This would result in these compounds being insoluble (resulting in measurements in water below the detection limit) and not bioavailable, resulting in no significant effects on the biota exposed to these sediments. Sediment quality guidelines will not be applicable in cases where hydrocarbons are not readily bioavailable (Chapman et al. 1996). Since these PAHs are not bioavailable, no data on PAH concentrations in fish tissues was collected and PAHs were not included in further consideration as COPCs for country foods quality.

Soil samples were not analyzed for PAH concentrations; however, coal PAHs in soil have low bioavailability (Hauck et al. 2007; Tang et al. 2007). Thus no significant effects on terrestrial biota would be expected if exposed to soil containing PAHs from coal.

The human receptors selected were toddlers (six months to four years of age) and adults (greater than 19 years of age; Richardson 1997; Health Canada 2010e, 2010g) and consumption rates of country foods were based on the study by Chan et al. (2011). Details are provided in Appendix 18-A.

Using the measured and modeled concentrations of COPCs in country foods, the EDI of each COPC for toddlers and adult receptors were estimated and are provided in Section 5.6 of Appendix 18-A. It was assumed that 100% of the country foods consumed were harvested from the country foods LSA 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 TRV is defined as the amount of metal per unit body weight (BW) that can be taken into the body each day (e.g., mg/kg BW/day) with no risk of adverse health effects. TRVs are safe levels below which there are minimal risks of adverse health effects and were obtained from Health Canada (Health Canada 2010c). Section 6 of Appendix 18-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 recommended maximum weekly intake (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 18-A.

For non-carcinogenic metals, an ER of less than 0.2 represents exposure that does not pose a significant health risk to human receptors (Health Canada 2010a). There is no health risk from COPCs to adults consuming representative country foods (i.e., moose, snowshoe hare, grouse, berries, and trout) based on the predicted and measured metal tissue concentrations and assumptions made in this report.

There is a slightly elevated ER of 0.49 for mercury in moose for toddlers, likely caused by an over-estimation of the concentration of mercury in moose tissue using a conservative wildlife model. Measurement of mercury in pooled moose meat samples collected from BC FN communities resulted in non-detectable mercury (Chan et al. 2011) in moose. Therefore, mercury from the consumption of moose meat is unlikely to present human health risks to toddlers.

Of the COPCs evaluated, only arsenic is considered carcinogenic through ingestion. Carcinogenic risks were estimated as incremental lifetime cancer risk (ILCR) estimates (Health Canada 2010a). An ILCR estimate that is less than 1×10^{-5} is normally considered acceptable. The calculated ILCRs for arsenic from all evaluated country foods (moose, snowshoe hare, grouse, trout, and berries) were less than 1×10^{-5} and therefore these representative foods can be considered safe for consumption at the current local consumption rates.

Assuming current maximum number of servings per week, RMWIs were greater than the current country foods weekly intakes for all of the country foods evaluated for toddlers and adults, and women of child-bearing age. However, some uncertainty exists regarding the current maximum number of servings, because consumption data obtained from (Chan et al. 2011) were averaged over the period of one year. It is possible that the intake rate for the week of maximum consumption for a particular country food is higher than this calculated annual average. The food with the lowest RMWI is grouse (7 and 4 servings a week for adults and toddlers, respectively) followed by trout, moose, berries, and snowshoe hare in increasing order.

The process of a country foods risk assessments has inherent uncertainties, which are discussed in detail in the baseline report (Appendix 18-A). Despite the uncertainties, a conservative approach was taken in order to overestimate rather than underestimate potential risks.

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 intake of >0.22 kg/day, the selenium concentration in fish tissue must be below 7.3 µg/g dry weight (dw). For a moderate fish intake of 0.11 kg/day, the selenium concentration in fish tissue must be below 14.5 µg/g dw. For a low fish intake of 0.03 kg/day, the selenium concentration in fish tissue must be below 75.0 µg/g dw. For the purposes of this assessment, the most conservative screening value (7.3 µg/g dw, based on the highest intake) has been used to compare to baseline fish tissue selenium concentrations in Slimy Sculpin, Bull Trout, Finescale Dace, Brook Trout, and Mountain Whitefish (Table 18.5-8).

Table 18.5-8. Baseline Fish Tissue Selenium Concentrations Compared to the High Fish Intake Guideline

Fish Species	Number of Sites Sampled	Total number of Fish	Minimum Selenium Concentration (µg/g dw)	Mean Selenium Concentration (µg/g dw)	95th Percentile Selenium Concentration (µg/g dw)	Maximum Selenium Concentration (µg/g dw)
Slimy Sculpin	10	101	2.61	5.08	9.46	10.8
Bull Trout	3	9	3.27	4.19	5.19	5.26
Finescale Dace	5	40	1.21	3.55	8.20	8.38
Brook Trout	3	9	2.02	4.35	5.88	6.15
Mountain Whitefish	2	4	4.03	4.58	5.08	5.14

Notes:
dw = dry weight
Shaded cells indicate the baseline fish tissue selenium concentration exceeds the BC MOE high fish intake screening value (7.3 µg/g dw, based on consumption of 220 grams of fish per day, every day; Beatty and Russo 2014).

The minimum and mean baseline fish tissue selenium concentrations were lower than the BC selenium guideline screening value for high fish consumption of 7.3 µg/g dw; however, the 95th percentile and maximum concentrations measured in Slimy Sculpin and Finescale Dace were greater than the BC guideline screening value for high fish consumption. Selenium tissue residues were highest in Slimy Sculpin sampled during Project baseline studies, compared to the other fish species (Table 18.5-8). Slimy Sculpin and Finescale Dace are not species consumed by humans but were sampled due to their abundance in the Murray River and tributaries. Furthermore, Slimy Sculpin have been used by other BC mining projects (e.g., Quintette Mine, Wolverine Mine, and Hermann Mine) as the sentinel species for effects monitoring, as they tend to have a greater selenium uptake than other fish species and have high site fidelity (Carmichael and Chapman 2006).

Overall, the country foods baseline predicted no unacceptable risk to people from the consumption of meat from moose, snowshoe hare, grouse, trout, and berries. Based on the measured and predicted levels of metals in these foods, the amounts currently consumed by the country foods harvesters are within the RMWIs. Thus, country foods harvesters may safely continue to eat these country foods.

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. Perception of risk from consumption of country foods is beyond the scope of the human health effects assessment (see Section 18.1).

18.5.3.4 Noise

Results from the noise monitoring program captured both the noise levels and the sources of the noise. Typical noise levels are (Cowan 1993):

- **0 dBA:** the threshold of human hearing (roughly a mosquito flying 3 m away);
- **10 dBA:** rustling leaves;
- **20 to 40 dBA:** very calm room with humming of refrigerator;
- **40 to 60 dBA:** normal conversation;
- **60 to 80 dBA:** passenger car at 10 m;
- **80 to 90 dBA:** major road at 10 m;
- **100 dBA:** jackhammer at 1 m;
- **110 to 130 dBA:** jet takeoff at 100 m; and
- **130 dBA:** human pain threshold.

Natural background noise sources observed at the Murray River monitoring stations included birds, mammals, wind, rain and thunder. Anthropogenic noise sources that were observed included aircraft, road vehicles, trains and mining activities. From the background data collected at the stations during the two monitoring periods:

- the mean noise (L_{eq}) levels averaged over the monitoring period ranged from 23.8 to 48.8 dBA;
- the hourly L_{90} levels averaged over the monitoring period ranged from 20.2 to 30.4 dBA;
- the absolute minimum (L_{min}) noise levels ranged from 16.6 to 22.5 dBA; and
- the absolute maximum (L_{max}) noise levels ranged from 51.6 to 96.2 dBA.

Typical baseline rural sound levels are around 35 dBA (nighttime) and 45 dBA (daytime) as presented in Alberta Energy and Utilities Board (EUB) Directive 38: Noise Control (Alberta ERCB 2007) and reproduced in the BC Oil and Gas Commission (OGC) British Columbia Noise Control Best Practice Guideline (BC Oil and Gas Commission 2009). The monitoring data within the study area are within this typical range of baseline rural sound levels.

18.6 ESTABLISHING THE SCOPE OF THE EFFECTS ASSESSMENT FOR HUMAN HEALTH

This section includes a description of the scoping process used to identify potentially affected VCs, select assessment boundaries, and identify the potential effects of the Project that are likely to arise from the Project's interaction with a VC. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Scoping of VCs for Human Health is similar to 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). The scoping process for the assessment of Human Health consisted of the following steps:

1. Conducting a desk-based review of available scientific data, technical reports, and other Project examples to compile a list of potentially affected VCs in the vicinity of the Project;
2. Carrying out detailed baseline study to fill information gaps regarding VCs;
3. Considering feedback from the EA Working Group on the proposed list of VCs included in the AIR and the EIS Guidelines;
4. Defining assessment boundaries for Human Health, and/or sub-components; and
5. Identifying key potential effects on VCs and/or sub-components.

These steps are described in detail below.

18.6.1 Selecting Valued Components

Selecting receptor VCs for assessment is done to focus the Application/EIS on the issues of highest concern. Receptor VCs are specific attributes of the biophysical and socio-economic environments that have environmental, social, economic, heritage, or health significance (BC EAO 2013; CEAA 2013b). Receptor VCs also have the potential to be indirectly affected by changes in the baseline condition of other environmental components thereby acting as receptors of that change. To be considered for assessment, a VC must be of recognized importance to society, the local community, or the environmental system, and there must be an actual or perceived likelihood that the receptor VC will be affected by the proposed Project. Receptor VCs are scoped during consultation with key stakeholders, including Aboriginal communities and the EA Working Group. Consideration of certain receptor VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

Canadian federal and provincial governments and health officials have accepted the World Health Organization's (WHO) 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).

This was expanded to include:

> *The extent to which an individual or group is able, on the one hand, to realize aspirations and to satisfy needs, and on the other, to change or cope with the environment. Health is therefore seen as a resource for everyday life, not the objective of living; it is seen as a positive concept emphasizing social and personal resources, as well as physical capabilities* (WHO 1948).

This definition indicates that all aspects of well-being should be considered when assessing human health, including physical, social, emotional, spiritual, and environmental impacts on health. There are many determinants of human health, such as: the physical environment (including environmental contaminants), lifestyle (e.g., smoking, drinking, diet, exercise, and coping skills), occupation, education, and the social and economic environment a person lives in (Health Canada 2000).

The physical environment factors contributing to human health are considered as sub-components because they 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 is assessed in this chapter, while other determinants of human health are included in Chapter 14, 15, 16, 17, and 20.

Following EIS guidelines, the Health Canada (2010g) *Useful Information for Environmental Assessments* document was used to scope relevant and appropriate receptor VCs and sub-components into the human health assessment. In their guidance to stakeholders and proponents, Health Canada (2010g) has suggested the following components be included in the assessment of human health:

- Air quality effects;
- Contamination of country foods;
- Drinking and recreational water quality;
- Radiological effects;
- Electric and magnetic fields (EMF) effects;
- Noise effects (or sound);
- Human health risk assessment (HHRA) and management;
- Multi-media toxicology (air, water, and soil); and
- First Nation health.

Valued components are also scoped into the environmental assessment based on issues raised during consultation on the draft application information requirements (dAIR) and EIS Guidelines with Aboriginal communities, government agencies, the public and stakeholders. Concerns about potential effects to human health have been raised by aboriginal groups (Appendix 2-C of Chapter 2), by the public and stakeholders (Appendix 2-E of Chapter 2), and by government (Appendix 2-G of Chapter 2).

Human health was identified as a receptor VC as a result of the scoping process, and refined as follows:

- Sub-component 1: Noise;
- Sub-component 2: Air Quality;
- Sub-component 3: Drinking Water; and
- Sub-component 4: Country Foods.

Predictive study results from the following intermediate components will be used to support the effects assessment for human health:

- Noise predictive study (modelling, Appendix 18-C);
- Air quality predictive study (modelling, Chapter 6 and Appendix 6-B);
- Water quality predictive study (modelling, Chapter 8 and Appendix 8-E); and

- Country foods screening level risk assessment (SLRA), if warranted based on the potential for changes in environmental media quality.

The indicators used for the sub-components are described in the sections below.

Selection of Water Quality as a VC

Aboriginal groups were concerned about water use and water quality (Appendix 2-C of Chapter 2). The SFN Knowledge and Use Study identified drinking water quality for wildlife as a concern but not for people (The Firelight Group 2014). Water quality can have an effect on human health through a direct (consumption of water) and indirect pathway (effect of water quality on the quality of country foods through the food chain). The quality of water has been extensively surveyed in baseline studies and will continuously be monitored throughout the life of the Project. Information on the potential contamination of drinking and recreational water is also identified by Health Canada as a key element beneficial to the agency in providing advice on the potential effects of a proposed project on human health (Health Canada 2010g). The quality of drinking water and water used for recreation was also identified as an issue by Health Canada in their comments to the dAIR. Fishing and other water-based recreation was identified as an issue by the BC Ministry of Jobs, Tourism and Skills Training in their comments to the dAIR. Aboriginal groups (MLIB, WMFN, and SFN) and the public and stakeholders raised water quality as an issue during Project notification, meetings, and Open Houses.

Because water quality can have potential effects to human health and has frequently been raised as an issue, drinking water quality has been selected as a VC in the human health effects assessment. The main indicator for drinking water quality is the concentrations of total metals, since guidelines for drinking water quality are based on total metal concentrations.

Selection of Air Quality as a VC

Aboriginal groups were concerned about dust control (Appendix 2-C of Chapter 2). The SFN Knowledge and Use Study identified dust deposition as a concern for wildlife and people (The Firelight Group 2014). Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience. Experience with previous projects is taken into consideration during the scoping of the dAIR and the EIS Guidelines as part of the BC EAO and the Agency processes. The effects of methane liberation and effects of particulate matter (dust deposition) on air quality were identified by Health Canada as issues in their comments to the dAIR (Appendix 2-G of Chapter 2).

Air quality was identified as a primary issue by the Murray River Coal Project Working Group in 2012. Information on air quality effects is also identified by Health Canada as a key element beneficial to the agency in providing advice on the potential effects of a proposed project on human health (Health Canada 2010g). Potential effects on air quality were also identified as an issue by the public and stakeholders during an Open House on November 24, 2012.

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 asthma). 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.

Air quality has been selected as a VC for human health, and the indicators are:

- NO_2;
- SO_2;
- CO;
- TSP;
- PM_{10};
- $PM_{2.5}$; and
- dustfall.

<u>Selection of Country Foods as a VC</u>

Concerns about country foods were raised by stakeholders and FNs (trappers, hunters) during the consultation process and TK/TU studies (Chapter 2, Appendix 2-C, Appendix 2-E). Concerns about potential game availability and contamination due to the Project were also raised in the SFN Knowledge and Use Study (The Firelight Group 2014). Country foods were also identified as a primary issue by the Murray River Coal Project Working Group in 2012. The quality of country foods (i.e., tissue metal concentration) can have a potential direct effect on human health through the ingestion pathway. This affects the health of country food harvesters and consumers.

The quality of country foods has been measured (i.e., in berries and fish) and modelled (i.e., in wildlife) as part of baseline studies. Food chain modelling relies on site-specific measured data on soil, vegetation, sediment, and water quality. The concentration of most metals and trace elements in humans is attributable to a large extent to the ingestion of food, with ingestion of water and inhalation of metals in air contributing to a much lesser extent. Because country foods are collected from the LSA and RSA and are important to human health, the country foods sub-component to the human health VC was included in the assessment, and the indicator is change in quality of country foods, as determined by change in quality of environmental media (i.e., soil, vegetation, water).

<u>Selection of Noise or Sound as a VC</u>

Noise effects can contribute to the human health through a number of effects (i.e., sleep disturbance, interference with speech communication, and annoyance) and was therefore selected as VC in the human health effects assessment.

During the scoping for the dAIR, Health Canada recommended the inclusion of noise into the dAIR document (Appendix 2-G of Chapter 2). In addition, Noise was identified by Aboriginal Groups as an issue to be included in the assessment during the consultation period (Appendix 2-C of Chapter 2). The SFN Knowledge and Use Study identified noise as a concern for caribou but not for people (The Firelight Group 2014). Noise was not identified as an issue by the Murray River Coal Project Working Group. Noise has been measured during baseline studies and will be periodically monitored during Project development and operation (see Section 24.4). As a result, noise has been selected as a VC for the human health assessment.

Indicators for noise are:

- sleep disturbance;
- interference with speech communication; and
- high annoyance (% HA).

18.6.1.1 Summary of Valued Components Selected for Assessment

As the result of the VC scoping process, the following VCs were selected for the assessment of human health (Table 18.6-1):

Table 18.6-1. Human Health Valued Components Included in the Effects Assessment

Valued Components	Identified by*				Rationale for Inclusion
	AG	G	P/S	Other	
Drinking Water Quality	X	X			Water quality can have potential effects to human health through direct and indirect pathways, and has frequently been raised as an issue by aboriginal groups and government.
Air Quality	X	X			Air quality can have a direct effect on human health, especially in sensitive people. It has been raised as a potential issue by Aboriginal Groups and Government.
Quality of Country Foods	X	X	X		Identified by trappers and hunters, Aboriginal Groups, and government. Consumption of country foods can have a potential direct effect on human health.
Noise	X	X			Identified as an issue by Health Canada and by Aboriginal Groups during the consultation period. Recommended for inclusion by Health Canada guidance document.

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

Table 18.6-2 identifies VCs suggested by Health Canada in (Health Canada 2010g) and other potential VCs that were excluded from the human health assessment as described in Section 18.6.1.

Table 18.6-2. Valued Components Excluded from the Effects Assessment for Human Health

Valued Components	Identified by*				Rationale for Exclusion
	AG	G	P/S	Other	
Radiological Effects		X			Radiological effects are not expected during coal mining activities and were not identified during the consultation process.
EMF Effects		X			EMF effects are not expected during coal mining activities and were not identified during the consultation process.
Human Health Risk Assessment (HHRA)		X			HHRA is inherently included in the baseline country foods risk assessment and the effects assessment, and is therefore not included as a separate VC.
Multi-media Toxicology		X			Multi-media Toxicology is inherent in the baseline country foods risk assessment and is therefore not included as a separate VC.
Dermal Exposure				X	Dermal exposure to chemicals or contaminated water is considered under occupational health hazards (Workplace Hazardous Materials Information System [WHMIS]) and will not be considered in this assessment. Off-duty workers are unlikely to be in contact with chemicals or contaminated water.
Incidental Soil Ingestion				X	Mainly of concern for children. Children are not considered receptors at the proposed underground mine and would not be affected by mineralized dust fall on soil.

**AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder; Other: professional judgement.*

EMF effects from power lines can cause weak electric currents to flow through the human body. However, the magnitude of the currents in power lines is not associated with any known short- or long-term health risks. Radiation was not selected as a VC because the proposed mine is a coal mine and radiation above background levels is not expected. Therefore, radiological effects and EMF effects were excluded from the list of potential VCs for the Murray River Project, because the Project activities (construction of the mine, underground mining, processing, and loading of coal) and infrastructure are not likely to generate radioactivity or EMFs with the potential to affect human health.

A HHRA approach is inherently incorporated in the selection of COPCs, potential human receptors, and exposure pathways, and used within the country foods risk assessment baseline and the human health effects assessment, and therefore does not need to be addressed separately as a VC. Similarly, multi-media toxicology (discussion of COPC's potential acute and chronic effects and rationale for selection of specific toxicity reference values) is incorporated within the human health effects assessment, and will therefore not be considered as a separate VC.

Dermal exposure to chemicals or contaminated water is considered as an occupational health hazard under the Workplace Hazardous Materials Information system (WHMIS) and will not be considered in this assessment. Off-duty workers are unlikely to be in contact with chemicals or potentially contaminated water. Therefore, health effects from dermal exposure are not included in this assessment.

There may be health effects from incidental soil ingestion. However, this is mainly a concern for children and since children are not considered receptors at the proposed mine, they would not be affected by mineralized dustfall on soil.

18.6.2 Selecting Assessment Boundaries

Assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the areas within, and times during which, the Project is expected to interact with the VCs, as well as the constraints that may be placed on the assessment of those interactions 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 through its VCs, as well as the trends in processes that may be relevant. Because Human Health relies on VCs with different technical boundaries, there is no one single LSA or RSA applicable to the Human Health assessment category.

18.6.2.1 Spatial Boundaries

Drinking Water

Local Study Area

The spatial boundary of the drinking water LSA is consistent with the surface water quality LSA (Figure 8.6-1 of Chapter 8). The drinking water LSA was selected to focus on the Mine Site Assessment Footprint and a larger, localized area of direct Project influence (Figure 18.6-1). The LSA incorporates the sub-watersheds on the east and west bank of the Murray River that may be potentially affected by the Shaft Site, the Decline Site, and the Coal Processing Site. Sub-watersheds included in the LSA include M20, Twenty, M17A, M17B, and M19A creeks. To assess potential localized effects on the headwaters of Mast and M19 creeks, the LSA boundaries deviate from the sub-watershed boundaries and are focused on the area most likely to be directly influenced by the Secondary Shaft Site (Mast Creek) and the linear access corridors (M19 Creek). The LSA incorporates the Murray River between water quality baseline site MR9 (upstream of all proposed Project activities) and MR7 (downstream of all Project discharges; Figure 8.6-1). For further details on the boundaries of the drinking water LSA, refer to surface water quality LSA in Chapter 8, Section 8.6.2.

Regional Study Area

The drinking water RSA (Figure 18.6-1) is adopted as the surface water quality RSA (Figure 8.6-1 of Chapter 8). The RSA is intended to encompass an area beyond which effects of the Project would not be expected. The RSA is aligned with the Murray River watershed boundaries (Figure 8.6-1).

Air Quality

Local Study Area

An LSA was not defined for air quality since the spatial boundaries for the effects assessment were based on the air quality modelling domain, which is equivalent to the air quality RSA (Figure 18.6-2).

Regional Study Area

The air quality RSA (Figure 18.6-2) follows the air quality modelling domain (Chapter 6, Assessment of Air Quality Effects). Any potential air quality effects to human health are not expected to extend beyond the air quality RSA, which is 72,758 ha in size.

Figure 18.6-1

Drinking Water Local and Regional Study Areas

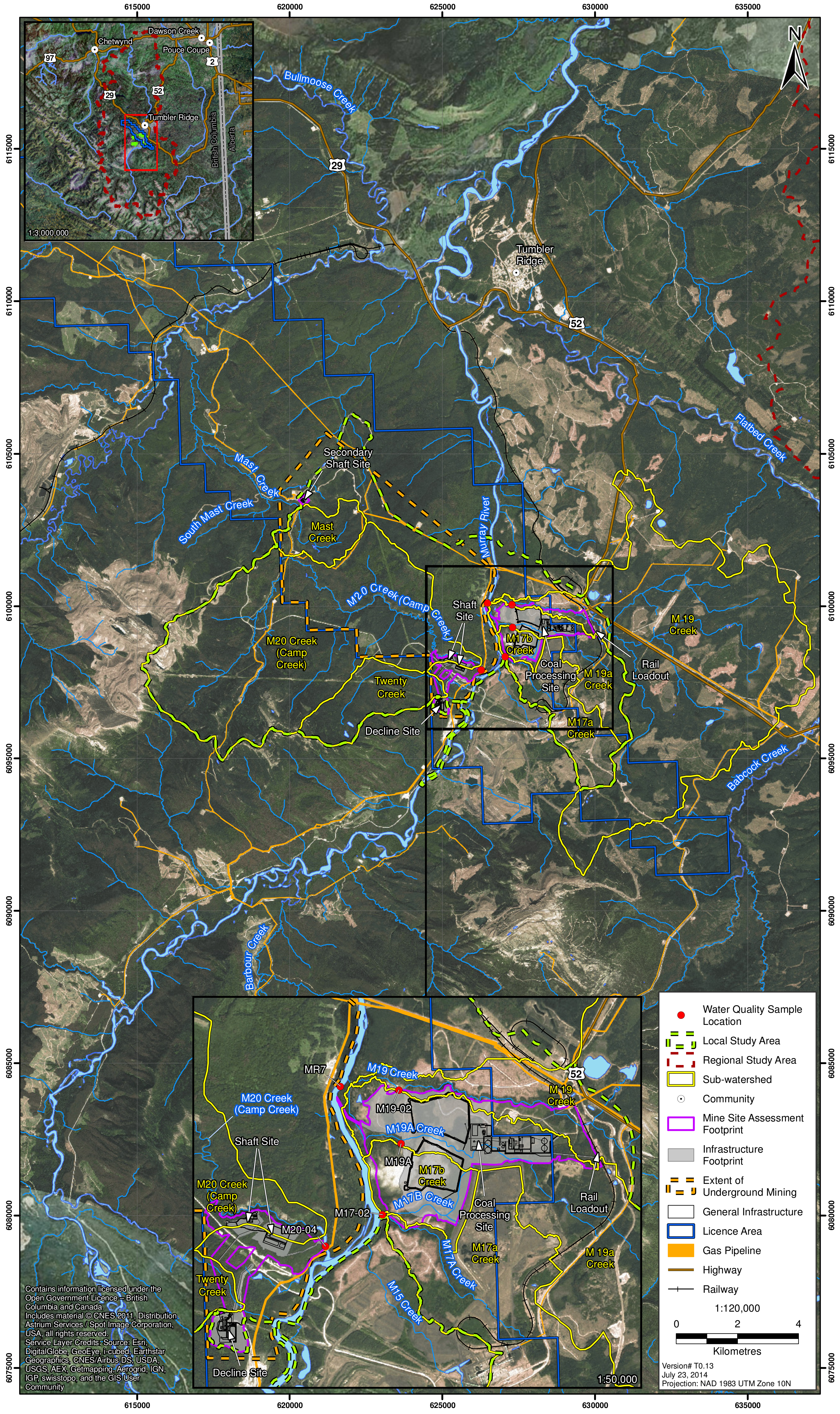
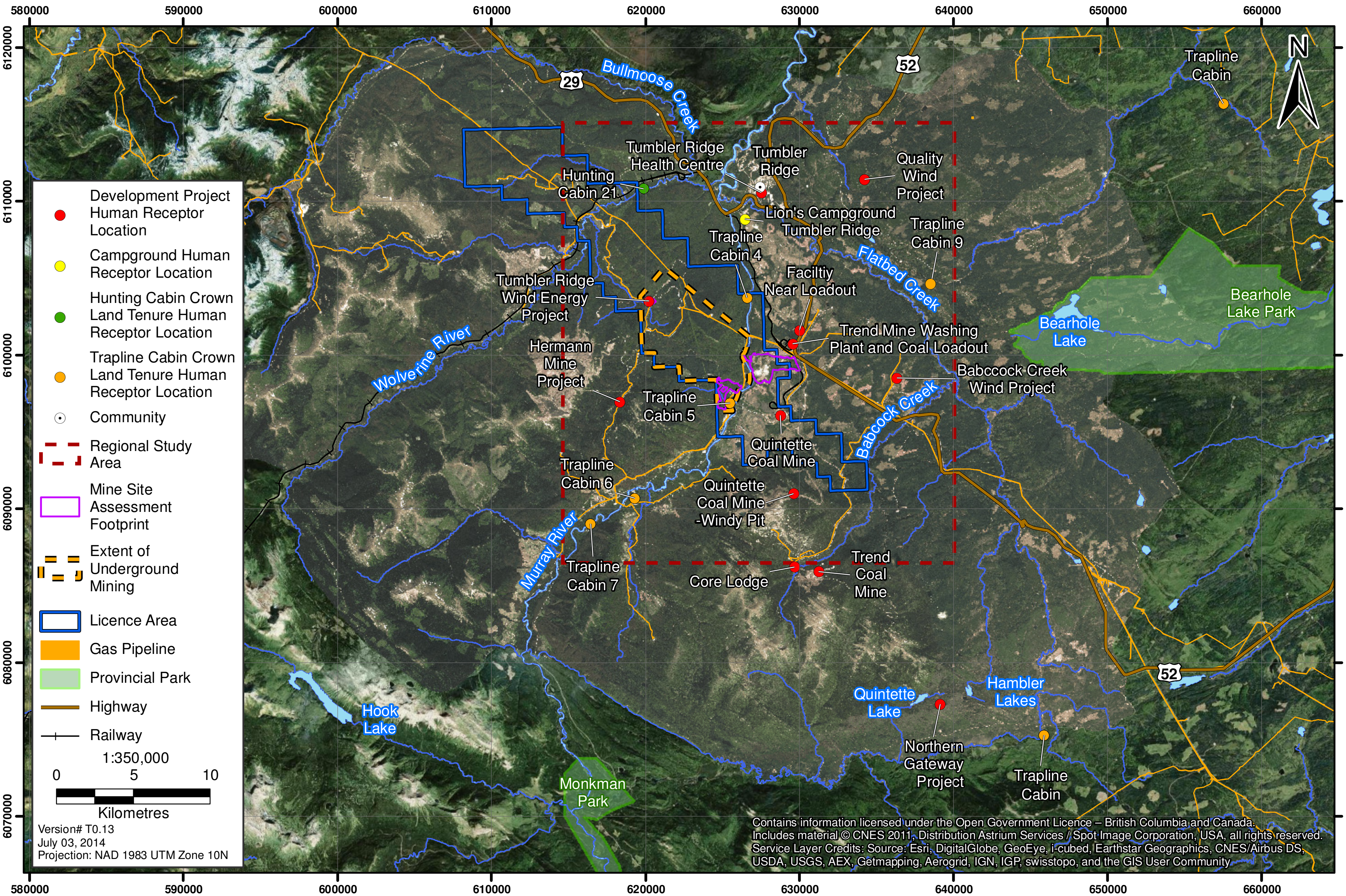


Figure 18.6-2
Air Quality Regional Study Area and Human Health Receptor Locations



Country Foods

Local Study Area

The country foods LSA (Figure 18.6-3) is 14,852 ha in size and encompasses an area surrounding the proposed Project infrastructure within which direct effects from the Project may be anticipated. The effects assessment LSA differs from the baseline LSA. The baseline study areas were defined prior to detailed infrastructure design; therefore, boundaries were designed to ensure extensive baseline surveys were conducted near all potential Project infrastructure. The LSA boundary was refined for the effects assessment to account for the final Project design, which included additional subsurface development, and focus the assessment to the areas potentially affected.

The country foods LSA was developed based on a combination of topographical features, such as natural terrain and watersheds to be ecologically relevant, and buffers around proposed Project infrastructure. The country foods LSA is identical to that used in the assessment of wildlife (Figure 13.5-1, Chapter 13) and terrestrial ecology (Chapter 11, Figure 11.5-1) to account for terrestrial country foods (i.e., moose, hare, grouse, and berries). Aquatic country foods (i.e., fish) could potentially be affected by surface water quality; therefore, the country foods LSA encompasses surface water where there is the highest potential for changes to water quality (in closest proximity to the Project site). It is expected that potential Project effects on the quality of country foods will only occur within the boundaries of the country foods LSA.

Regional Study Area

The country foods RSA (Figure 18.6-3) is 227,616 ha in size and is intended to encompass an area beyond which effects of the Project would not be expected. Selection of the RSA boundaries took into account the area that provides habitat for wildlife species that may come into contact with proposed Project infrastructure during the course of a season or a lifetime. Other ecological factors such as height of land were also considered when delineating boundaries.

Noise

Local Study Area

The study area for the noise VC is defined as the area that could potentially be affected by noise emission sources associated with the Project, and is equivalent to the noise modelling domain (Figure 18.6-4). This study area is described as the RSA and an LSA is not defined.

Regional Study Area

The noise RSA (Figure 18.6-4) is based on the noise modelling domain. The RSA was defined by the modelled noise contours, which were plotted up to 10 dB lower than each criteria limit. Because the noise decibel scale is logarithmic, any noise that is 10 dB lower than the existing noise will not add significantly (<0.5 dB) to the overall level. Any noise effects to human health are not expected to extend beyond this boundary. Specific receptor locations for probable human presence (workers at other adjacent infrastructure and activity sites, and other land users), have been located inside the study area (Figure 18.6-4) and will be included in the noise model. Any project related noise effects to human health are not expected to extend beyond the noise RSA.

Figure 18.6-3
Country Foods Local and Regional Study Areas

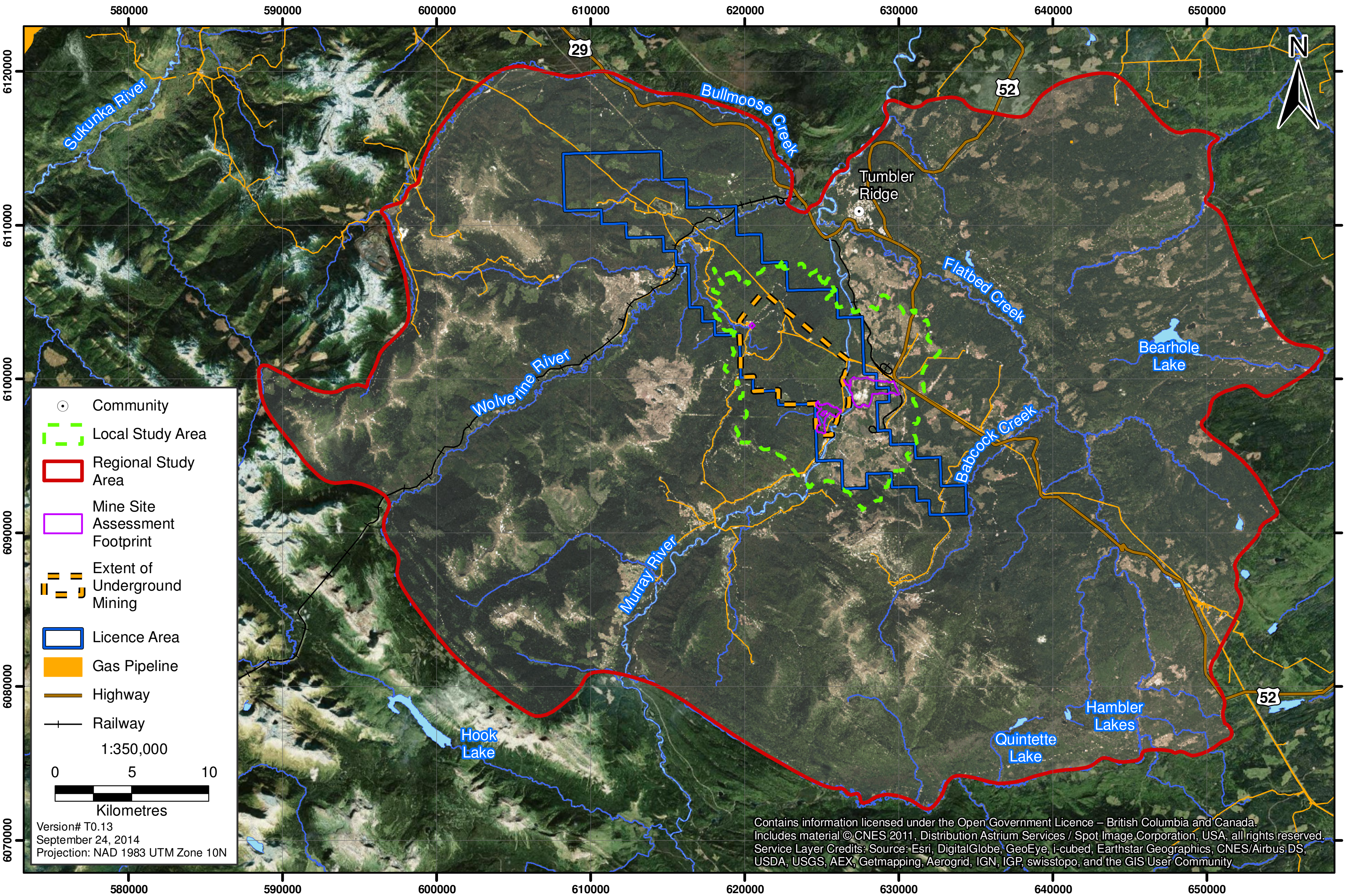
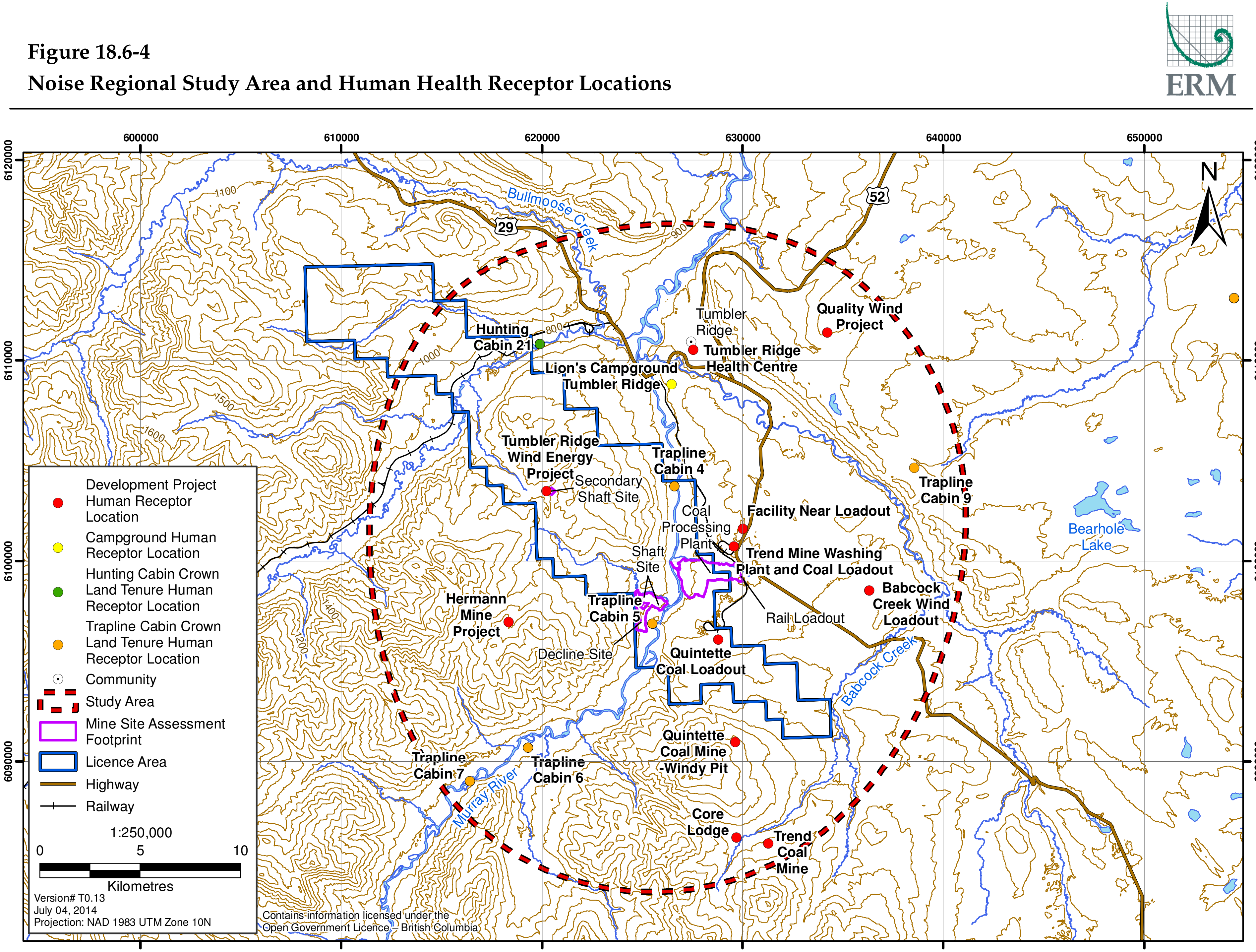


Figure 18.6-4

Noise Regional Study Area and Human Health Receptor Locations



18.6.2.2 Temporal Boundaries

Human health can potentially be affected throughout the life of the mine, encompassing the Construction, Operation, Decommissioning and Reclamation, and Post-Closure phases. The temporal boundaries of the Project include the following:

- **Construction**: 3 years;
- **Operation**: 25-year run-of-mine life;
- **Decommissioning and Reclamation**: 3 years (includes project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post-Closure**: 30 years (includes ongoing reclamation activities and post-closure monitoring).

For the assessment of human health from contaminants in air, is it generally assumed that the Operation phase will have a higher potential for effects than the Construction, Decommissioning and Reclamation, and Post-Closure phases and, to be conservative, the “worst case” scenario was assessed. If no effects are predicted in Operation, it is unlikely that effects will occur to human health during the other phases of the Project.

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.

The potential for effects to human health from the consumption of country foods took into consideration the results of both the air quality (i.e., fugitive dust) and water quality predictive models. For terrestrial country foods (e.g., berries and wildlife), fugitive dust generated due to Project activities has the greatest potential to affect the quality of the country food; therefore, Operation was assessed as the worst-case scenario (i.e., consistent with air quality). For aquatic country foods (i.e., fish), the potential for effects to human health were assessed based on the results of the water quality predictive model, and considered all phases of the Project.

Noise effects will be assessed during the busiest year of Construction and an average typical year of Operation, to predict the annual average daily noise levels during typical worst case years of the Project in order conservatively identify potential effects. Noise from the Decommissioning and Reclamation, and Post-Closure phases is expected to be less significant than the Construction and Operation phases and thus, is not considered.

18.6.2.3 Administrative Boundaries

No administrative boundaries apply to the human health effects assessment. FNs, hunters, trappers, and outfitters were assumed to hunt, fish, and collect country foods throughout the LSA and RSA and were not constrained by administrative boundaries.

18.6.2.4 Technical Boundaries – Human Receptor Locations and Other Considerations

Human receptor locations also influence 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 18.1). The following sections describe the locations of human receptors for the purpose of the effects assessment (Section 18.7), and how the human receptor locations influence the scope or boundaries for the effects assessment.

Drinking Water

The drinking water assessment assumes that land users (FN and non-FN hunters, trappers, and recreationists) may drink surface water from streams anywhere inside the LSA, which may or may not be treated for chemical contaminants (i.e., metals), dependent on the preferred practice of the land user. Therefore, potential receptors for the drinking water quality VC are adult land users and toddlers (the most sensitive receptor), throughout the LSA and RSA.

Groundwater wells are also used for drinking water and within the RSA the community of Tumbler Ridge, the Wolverine Mine, and the Quintette Mine obtain drinking water from wells (Figure 18.3-2). However, well water treatment according to the *BC Drinking Water Protection Act* (2001) will ensure the protection of human health. Further details on potential groundwater effects on human health can be found in Section 18.7.1.

Air Quality

Evaluation of the Project area and the air quality modelling domain led to the identification of 18 human receptor locations to be included in the health assessment. Data sources used to determine human receptor locations included permanent or temporary locations identified in Appendix 16-A (Murray River Project: Non-traditional Land Use Baseline) as well as the Murray River Coal Project: Ethnographic Overview and Traditional Knowledge and Use Desk-based Research Report (Rescan 2013b). Specific receptor locations for human presence (e.g., workers at other adjacent infrastructure and activity sites and land users), and soil and vegetation baseline sampling locations were included in the air quality model. The Saulteau First Nations Knowledge and Use Study (The Firelight Group 2014) indicates that there are potential human health receptor locations within the air quality LSA; however, this report was not available when the air quality modelling was completed.

The 18 specific air quality human receptor locations (Figure 18.6-2) are:

- the Tumbler Ridge Health Centre (the most sensitive receptor location in Tumbler Ridge);
- land users staying at the Core Lodge and Lions Campground;
- users of Hunting Cabin 21 and Trapline Cabins 4, 5, 6, 7, and 9; and
- workers at other adjacent infrastructure and activity sites (Hermann Mine, Quintette Coal Mine - Windy Pit, Quintette Coal Loadout, Trend Mine, Trend Mine washing plant/coal loadout, Facility near loadout, Tumbler Ridge Wind Energy Project, Quality Wind Project, and Babcock Creek wind loadout).

Country Foods

The country foods assessment assumes that land users (FN and non-FN hunters, trappers, and recreationists) consume country foods harvested from throughout the LSA, thus there are no specific receptor locations. The country foods assessment boundaries during the life of the Project are the same as those used for the baseline study (i.e., the country foods LSA and RSA; see Appendix 18-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 LSA. Potential receptors for the country foods VC are adult land users and toddlers (the most sensitive receptor).

Noise

Human receptor locations for noise are categorized into three groups: residing non-worker human receptors, Project workers, and workers from adjacent infrastructure and activity sites. However, since Project employees will not be sleeping in camps on-site but will be returning to Tumbler Ridge to sleep, and are covered under laws and regulations by WorkSafe BC (WorkSafe BC 2014) and the Health, Safety and Reclamation Code for Mines in BC (BC MEMPR 2008) while at work, this group was scoped out of the noise human health assessment. It was assumed that workers from adjacent infrastructure and activity sites would also not be sleeping on-site at their respective Projects and would likely return to Tumbler Ridge. Therefore, sleep disturbance was not assessed for workers at adjacent infrastructure and activity sites but as a conservative measure, Project-related noise effects on workers from adjacent infrastructure and activity sites were assessed during the day and at night since workers may be working night shifts.

The noise RSA overlaps with or is in close proximity to the MLIB, SFN, WBFN, BRFN, and HLFN Traditional Territories. The SFN have indicated use of a bridge over the Murray River in the southwestern section of the Project footprint as a focal point for access to hunting, fishing, camping, and berry and plant collection (The Firelight Group 2014). In addition, the road running along the western bank of Murray River is used by the SFN for hunting, fishing, berry picking, and other activities (The Firelight Group 2014). However, no specific cabin, residence, or campground was identified by MLIB, SFN, WMFN, BRFN, or HLFN within the Noise RSA.

The same 18 human receptor locations considered for air quality were also considered for noise. However, four (4) of these human health receptors are too distant from noise sources to experience Project-related noise, and were thus excluded: Trend Coal Mine, Core Lodge, and Trapline Cabins 7 and 9 (Figure 18.6-4).

18.6.3 Identifying Potential Effects on Human Health

The purpose of this section is to describe the types of potential effects that can result from the interaction of the Project's components and activities with each sub-component by which human health can be affected (i.e., noise, air quality, drinking water quality, country foods quality). Effects to human health could potentially occur during all phases of the Project. Components and activities for each phase are discussed to describe the pathways that can lead from components/activities to effects on human health (Sections 18.6.3.1. to 18.6.3.4). Note that the potential for spills and accidents involving large quantities of petroleum products or other chemicals are not considered here since this is addressed in Chapter 21 (Accidents and Malfunctions).

Linkages will include, where relevant, both direct and indirect effects. A direct effect (or direct pathway) is an effect that results from a direct interaction between the Project and a human health VC, and includes:

- Changes in air quality (i.e., CAC concentrations) and potential health effects due to inhalation of airborne CACs;
- Changes in the quality of surface water and potential health effects due to consumption of the surface water as drinking water; or,
- Changes in noise levels and potential health effects due to noise on human receptors.

Indirect effects (indirect pathways) are the result of direct effects of the Project on one VC that could lead to other effects, and includes:

- Changes in soil or vegetation quality due to the deposition of fugitive dust containing contaminants that could affect the quality of country foods through uptake via the food chain, with the potential for subsequent health effects to country foods consumers; or
- changes in water quality that could affect the quality of country foods through the food chain, with the potential for subsequent health effects to country foods consumers.

The following sections will identify the potential effects to human health from activities in each Project phase, considering the potential for direct or indirect effects. Potential linkages between Project components and activities and the four human health VCs (i.e., drinking water quality, air quality, quality of country foods, and noise) are listed in Table 18.6-3. Interactions that are marked red or yellow in Table 18.6-3 are interactions with potential moderate or major adverse effects and will be carried forward for further analysis in the effects assessment, while those interactions that are green have negligible to minor effects predicted and will not be discussed further except to identify standard operating practises and mitigation measures (Section 18.7.2) that are well known and will be used to address these minor concerns.

18.6.3.1 Construction

During the three-year Construction phase, activities will include:

- the establishment of water management structures (e.g., embankments, sedimentation ponds, water treatment facilities, groundwater wells), and site drainage, including a system of diversion channels to divert contact and non-contact water;
- site clearing and grubbing, including soil salvage as appropriate;
- excavation and foundation preparation; and
- construction of buildings and processing facilities.

Table 18.6-3. Ranking Potential Effects On Human Health

Project Activities		Potential Effects on Human Health: Effects on Drinking Water Quality	Effects on Air Quality	Effects on Country Foods Quality	Effects on Sound
Construction	**Underground Mine**				
	Construction of Production Decline (2 headings - surface and underground)	L	M	M	M
	Haul of waste rock from Production Decline portal to Shaft Site	L	M	M	M
	Ventilation during construction	L	M	M	L
	Development mining of underground service bays, sumps, conveyor headings, etc.	L	M	M	M
	Construct underground conveyor system	L	M	M	L
	Coal Processing Site				
	Surface Preparation				
	Establish site drainage and water management	M	L	L	L
	Site clearing and stripping (CPP site, CCR North)	M	M	M	M
	Soil salvage for reclamation	L	M	M	L
	Upgrade access roads, parking and laydown areas	M	M	M	M
	Heavy machinery use	M	M	M	M
	Buildings and Services				
	Install domestic water system	L	L	L	L
	Install sanitary sewer system	L	L	L	L
	Install natural gas and electricity distribution network	L	L	L	L
	Construct main fuel station	L	M	M	M
	Construct buildings (e.g., maintenance, administration, warehouse)	L	M	M	M
	Construct raw coal and clean coal stockpile areas	L	M	M	M
	Construct coal preparation plant buildings and install/commission equipment	L	M	M	M
	Construct surface conveyor system	L	M	M	M
	Construct rail load-out facilities	L	M	M	M
	Shaft Site				
	Upgrades to infrastructure within existing site	L	L	L	M
	Addition of waste rock within existing storage area	L	M	M	L
	Management of runoff from waste rock pile and release to receiving environment (M20 Creek)	M	L	L	L
	Decline Site				
	Upgrades to infrastructure within existing site	L	L	L	M
	Management of water from underground activities and release by exfiltration to ground	M	L	L	L
	Traffic and Transportation				
	Transportation of materials to and from site	L	M	M	M
	Recycling and solid waste disposal	L	M	M	L
	Shuttling workforce to and from site	L	M	M	M
	Workforce and Administration				
	Hiring and management of workforce	L	L	L	L
	Taxes, contracts, and purchases	L	L	L	L

(continued)

Table 18.6-3. Ranking Potential Effects On Human Health (continued)

Project Activities		Potential Effects on Human Health			
		Effects on Drinking Water Quality	Effects on Air Quality	Effects on Country Foods Quality	Effects on Sound
Operations	**Underground Mine**				
	Longwall panel mining, and development mining	L	M	M	L
	Ventilation from underground	L	M	M	L
	Methane management	L	M	M	L
	Secondary shaft construction	L	L	L	M
	Underground seepage collection and water management	L	L	L	L
	Surface subsidence	L	L	L	L
	Coal Processing Site				
	Coal Processing Plant				
	Stockpiles of raw coal	L	M	M	L
	Operation of coal preparation plant and conveyor system	L	M	M	M
	Stockpiles of clean coal and middlings	L	M	M	L
	Operation of rail loadout	L	M	M	M
	CCR				
	CCR Pile development	M	M	M	L
	Site clearing and stripping (expansion of CCR North, construction of CCR South)	M	M	M	M
	Seepage collection system	M	L	L	L
	Water Management				
	Management of water brought to surface from underground	L	L	L	L
	Management of seepage from CCR	L	L	L	L
	Management of other site contact water	L	L	L	L
	Maintenance of site ditching and water management infrastructure	M	L	L	L
	Release of excess contact water to receiving environment	H	L	L	L
	Shaft Site				
	Maintenance of infrastructure within existing site	L	L	L	L
	Progressive reclamation of waste rock pile	L	M	M	M
	Management of runoff from waste rock pile and release to receiving environment (M20 Creek)	H	L	L	L
	Decline Site				
	Maintenance of infrastructure within existing site	L	L	L	L
	Secondary Shafts Site				
	Site preparation and construction of shafts	M	M	M	M
	Maintenance of infrastructure within existing site	L	L	L	L
	Utilities, Power, and Waste Handling				
	Electrical power use	L	L	L	L
	Natural gas use	L	M	M	L
	Domestic water use	L	L	L	L
	Domestic sewage handling	L	L	L	L
	Recycling and solid waste disposal	L	L	L	L

(continued)

Table 18.6-3. Ranking Potential Effects On Human Health (completed)

Project Activities		Potential Effects on Human Health			
		Effects on Drinking Water Quality	Effects on Air Quality	Effects on Country Foods Quality	Effects on Sound
Operations *(cont'd)*	**Heavy Machinery, Traffic, and Transportation**				
	Shuttling workforce to and from site	L	M	M	M
	Transportation of materials to and from site	L	M	M	M
	Surface mobile equipment use	L	M	M	M
	Road maintenance	M	M	M	M
	Fuel storage	L	L	L	L
	Workforce and Administration				
	Hiring and management of workforce	L	L	L	L
	Taxes, contracts, and purchases	L	L	L	L
Decommissioning and Reclamation	**Infrastructure Removal and Site Reclamation**				
	Facility tear down and removal	L	M	M	M
	Reclamation of plant site	L	M	M	M
	Reclamation of on-site roads and rail lines	M	M	M	M
	Recycling and solid waste disposal	L	M	M	M
	Heavy Machinery, Traffic, and Transportation				
	Shuttling workforce to and from site	L	M	M	M
	Transportation of materials to and from site	L	M	M	M
	Surface mobile equipment use	L	M	M	M
	Fuel storage	L	L	L	L
	CCR				
	Reclamation of CCR	M	M	M	M
	Seepage collection system	H	L	L	L
	Site water management and discharge to receiving environment	H	L	L	L
	Underground Mine				
	Infrastructure tear down and removal	L	M	M	M
	Geotechnical and hydrogeological assessment and bulkhead installation	L	L	L	L
	Groundwater monitoring	L	L	L	L
	Workforce and Administration				
	Hiring and management of workforce	L	L	L	L
	Taxes, contracts, and purchases	L	L	L	L
Post Closure	**Shaft Site**				
	Waste rock pile seepage monitoring	L	L	L	L
	CCR				
	Seepage collection system	H	L	L	L
	Site water management and discharge to receiving environment	H	L	L	L
	Underground Mine				
	Groundwater monitoring	L	L	L	L

L	*Negligible to minor adverse effect expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate adverse effect requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

Construction activities have the potential to affect the quality of surface water. Surface runoff from construction of buildings and facilities at the Coal Processing Site and excavation at the Shaft and Decline sites, from grading, cleaning, and rock storage areas may cause sedimentation and associated water chemistry effects. Water quality was modeled for the Construction phase (Appendix 8-E).

Construction activities will also generate air emissions, such as dust from moving rocks, waste rock and soils at the Coal Processing Site and the Shaft and Decline sites. Certain aspects of the construction of the Underground Mine, such as hauling of waste rock and emissions from the ventilation can also have effects on human health. Traffic and transportation of materials, wastes, recycling, and the workforce to and from the Project sites may also have potential effects on human health due to emissions and dust. However, the generation of air contaminants from the Project is expected to be highest during the Operation phase, which is predicted to last for 25 years, and lower during Construction, which is predicted to last for 3 years. Air emissions were modeled for the worst-case scenario (i.e., during Operation phase) and, therefore, air emissions from Construction period were not modeled.

Country foods could be affected if either water quality is altered or fugitive dust settles onto soil or vegetation. Potential linkages in Table 18.6-3 were based on whether linkages were identified for either water quality or air quality.

Noise emitted from activities and equipment during Construction was modeled (Appendix 18-C), and included consideration of potential noise-generating activities at the Shaft and Decline sites, Coal Processing Site, and material transport.

Table 18.6-3 provides all potential linkages between the Project activities and components and the human health VC.

18.6.3.2 Operation

The Operation phase consists of the underground longwall mining of metallurgical coal. The underground workings will roughly correspond to an aboveground footprint of 37 km^2. Two accesses will be developed from surface to underground: one decline for coal haulage and one shaft for transportation of personnel, materials, and equipment, and ventilation. A secondary shaft site will be constructed subsequently for the full mine. Run-of-mine (ROM) coal will enter the coal preparation plant, where it will be crushed, and then transferred through a series of sizing processes. Three components are produced through the preparation plant: clean coal, middlings, and rejects. The clean coal and middlings are directed to the rail loadout, while the rejects are directed to the CCR piles.

Operation phase activities related to the CCR pile development, site clearing, seepage collection, and other water management strategies have the potential to affect water quality. Discharge of excess contact water to the receiving environment and management of runoff from the waste rock pile are two activities that have the most potential to affect water quality.

The Operation phase was selected for assessment for air quality, since this phase was considered to have the highest potential for Project-related air emissions related to the processing and storing of coal (Chapter 6). Other phases of the Project would be expected to have lower emissions, and thus lower potential risk to human health due to air quality. Effects may occur due to inhalation of emissions from vehicles and machinery, dust particulates, and dust-associated metals generated by open-air transportation and storage of ROM coal, processed coal, and CCR and waste rock.

Country foods could be affected if either water quality is altered or fugitive dust settles onto soil or vegetation. Potential linkages in Table 18.6-3 were based on whether linkages were identified for either water quality or air quality.

Noise emitted from activities and equipment during the Operation phase was modeled (Appendix 18-C), and included consideration of potential noise-generating activities at the Shaft and Decline sites, Coal Processing Site, and material transport.

Table 18.6-3 provides all potential linkages between the Project activities and components and the human health VC.

18.6.3.3 Decommissioning and Reclamation

Activities during the Decommissioning and Reclamation phase will be defined in the closure plan that will be developed for the Murray River Coal Project under the requirements of the BC Mines Act (1996) and the Health, Safety and Reclamation Code for Mines in British Columbia (BC MEMPR 2008). The scoping for potential effects and the assessment of residual effects therefore relies on the preliminary conceptual closure plan presented in the Project Description (Chapter 3). The Decommissioning and Reclamation phase is predicted to last three years.

Water quality in the receiving environment may have a potential effect on surface drinking water sources for land users and was modeled (Chapter 8, Appendix 8-E). Effects to water quality could occur due to seepage collection, site water management and discharges to the receiving environment, or due to reclamation activities that could increase erosion and sedimentation. Water quality could continue to have an indirect effect on human health (via the food chain) from the consumption of country foods.

Potential Project-related effects to both air quality and noise are predicted to be much lower and of much shorter duration during the Decommissioning and Reclamation phase than during the Operation phase. Because only worst-case scenarios were modeled for air quality and noise, the Decommissioning and Reclamation phase emissions were not modeled.

Table 18.6-3 provides all potential linkages between the Project activities and components and the human health VC.

18.6.3.4 Post-Closure

The Post-Closure phase will last until long-term environmental objectives are achieved (currently estimated to be 30 years). Surface and groundwater monitoring will take place during this phase.

Water quality in the receiving environment may have a potential effect on surface drinking water sources for land users and was modeled (Chapter 8, Appendix 8-D). Effects to water quality could occur due to seepage collection or site water management and discharges to the receiving environment. Water quality could continue to have an indirect effect on human health (via the food chain) from the consumption of country foods.

No effects on human health from noise and changes in air quality during Post-Closure would be expected, as most activities will have ceased. Minor traffic for ongoing maintenance and monitoring activities will produce emissions; however, the emissions are considered negligible compared to emissions during the Construction and Operation phases.

Table 18.6-3 provides all potential linkages between the Project activities and components and the human health VC.

18.7 EFFECTS ASSESSMENT AND MITIGATION FOR HUMAN HEALTH

Figure 18.7-1 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, or noise. Quantifiable endpoints to assess the effects to human health and are summarized in Table 18.7-1. These endpoints will be assessed for different phases. The selection of phases for assessment were made based on assumptions that characterized a particular phase as the “worst case” phase to provide the most conservative assessment.

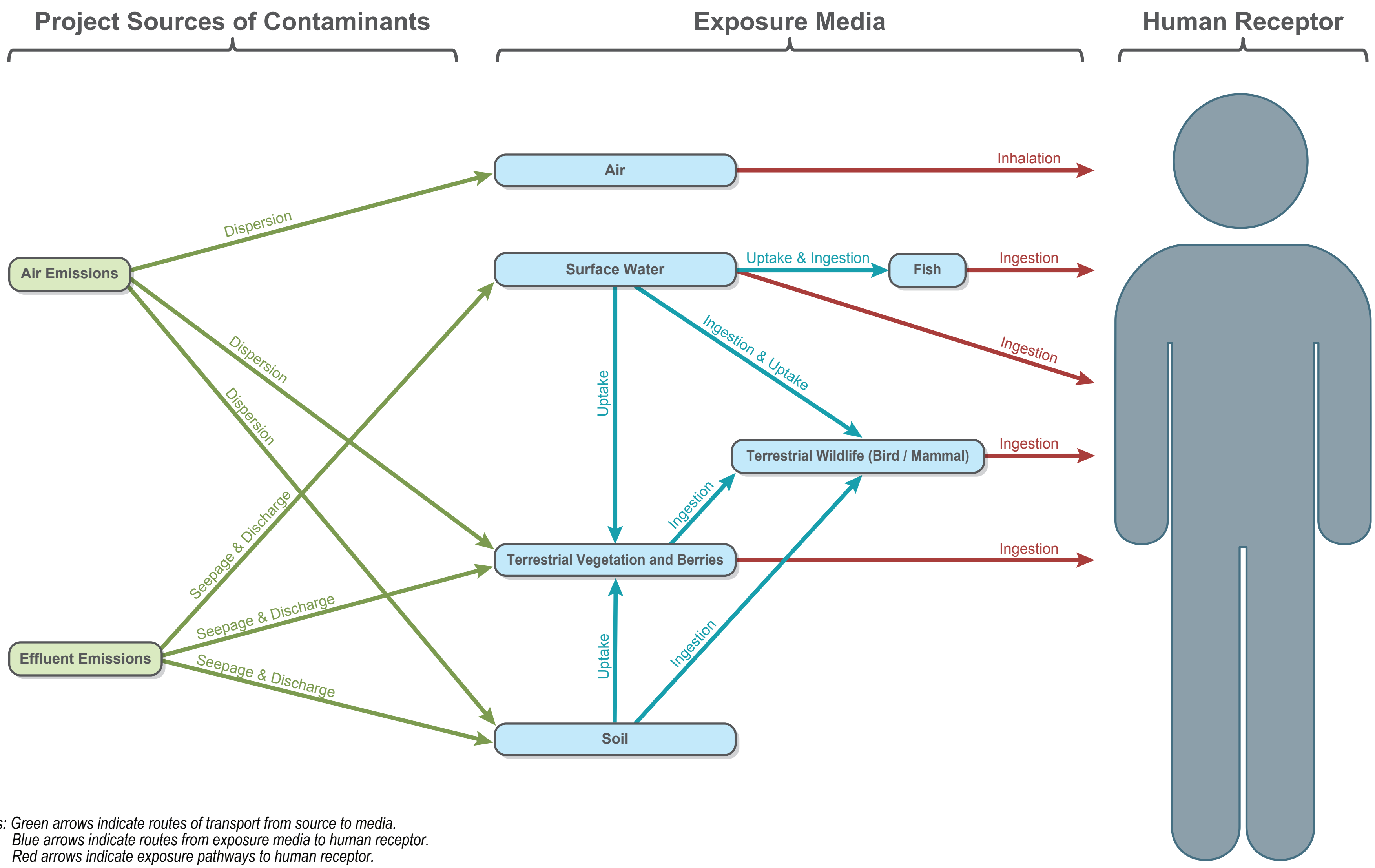
The following sections describe the key potential effects that human receptors may experience as a result of Project-related noise, changes in air quality, drinking water quality, and country foods quality in further detail. Key potential effects were identified in Section 18.6.3 as activities or components 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 also described.

18.7.1 Key Effects on Human Health from Drinking Water Quality

The purpose of the drinking water effects assessment is to evaluate the potential for Project activities to affect human health from the ingestion of water (Figure 18.7-1). The assessment of key effects to human health from drinking water relies on the baseline water quality collected between 2010 and 2014 (Appendix 8-D) and the Project-related water quality predictions as presented in Chapter 8 and Appendix 8-E. All water quality model assumptions are presented in Appendix 8-E. The pathways through which water quality could be affected by the Project are described in Chapter 8, Section 8.6.3.1.

Figure 18.7-1

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 from exposure media to human receptor.
Red arrows indicate exposure pathways to human receptor.

Table 18.7-1. Approach for Assessing Potential Effects to Human Health

Summary of Potential Effects to be Assessed for Human Health	Assessment Phase
Potential human health effects from the consumption of drinking water	
• Hazard quotient (HQ) based on predicted water quality from the water quality model and the BC or Canadian DWQGs • If drinking water guidelines are exceeded (i.e., HQ > 1), an exposure ratio based on estimated daily intake and the tolerable daily intake will be calculated • If a drinking water guideline for a carcinogenic metal is exceeded (i.e., HQ > 1 for arsenic), the incremental lifetime cancer risk will be calculated	• Construction • Operation • Decommissioning and Reclamation • Post-Closure
Potential human health effects from changes to air quality	
• HQ based on predicted air quality from the air quality model and the BC and Canadian air quality guidelines and objectives • If air quality guidelines and objectives are exceeded (HQ > 1), an exposure ratio based on inhalation rates and time spent at the site will be calculated	• Operation
Potential human health effects from the consumption of country food	
• Selection of contaminants of potential concern (COPCs) based on applicable guidelines • For identified COPCs, exposure ratio based on estimated daily intake and the tolerable daily intake • Recommended maximum weekly intake, based on COPC concentrations • Incremental lifetime cancer risk, based on COPC concentrations	• Operation (for terrestrial country foods, based on predicted air quality) • All phases (for aquatic country foods, based on predicted water quality)
Potential human health effects from noise	
• Sleep disturbance • Interference with speech communication • Percent highly annoyed	• Construction • Operation

HD Mining has engaged First Nations to obtain traditional knowledge/traditional use (TK/TU) information. Recently, a report on SFN traditional and current land use has become available (The Firelight Group 2014) and while the report provides information on locations where recreation takes place in waterways within the RSA, no information was provided on the frequency the waterways are used. Information from other First Nations groups was not provided to HD Mining.

Although no specific surface water bodies or springs within the LSA were identified as drinking water sources 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. This is a conservative assumption, because the LSA is within driving distance from Tumbler Ridge and other communities, and land users are likely to bring treated drinking water from the community water systems or bottled water for day use. However, it is possible that people may stay at camp sites multiple days and may drink untreated surface water. Health Canada recommends that water collected from surface waterbodies always be treated before using it for 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 un-treated water. Generally, personal water purification systems are not designed to treat metals or other chemicals.

Potential human health effects from the ingestion of 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 land user spends in the area.

Toxicity from metals can result in a variety of health effects depending on the individual contaminant and effects may range from carcinogenic to non-carcinogenic (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 drinking water will only occur if humans drink water enough water with sufficiently high concentrations of contaminants, such that toxicity thresholds are surpassed.

There are two sewage treatment systems proposed for the Project: one at the Decline Site and one at the Coal Processing Site (Chapter 3). Sewage treatment plant effluent can be a potential source for bacterial contamination, especially in conditions of high suspended solids (turbidity), and nutrients. Some bacteria can cause intestinal upsets, such as abdominal pain and diarrhea. However, it is unlikely that people will come into direct contact with sewage effluent. Generally, conditions that could cause adverse effects are unlikely to be present, particularly if surface water is treated for microbiological contamination prior to drinking, as recommended by Health Canada (Health Canada 2008).

In addition to surface water, ggroundwater wells can also be used as sources of drinking water. Within the RSA, the community of Tumbler Ridge, the Wolverine Mine, and the Quintette Mine obtain drinking water from groundwater wells (Figure 18.3-2). These groundwater wells would be subject to to the *BC Drinking Water Protection Act* (2001) and would need to meet the requirement to provide potable water, which will ensure the protection of human health.

Chapter 7 of the Application/EIS covered Project-related effects to groundwater. As stated in Section 7.7.4, during Operation, according to the mine plan, the groundwater flow into the underground mine zone will be collected and managed. Groundwater inflow into the underground mine will be collected in the mine water sump and sedimentation pond at the Underground Operation Hub and then be pumped to water management facilities at the surface. After providing make-up water to the Coal Preparation Plant, excess water will be discharged to the Murray River. Therefore, it is expected that during Operation, groundwater quality in the mine area will not be affected by dewatering of the mine.

The closest groundwater supply well (at the Quintette Mine) is located on the east side of Murray River (see Figure 7.3-3 in Section 7.3.4), and therefore no effect is expected to the water quality in any of the supply wells because of the proposed Project during Operation.

After mining is complete, the mine cavity will be infilled with collapses of rock (gob) and flooded with water, with the water table expected to recover eventually to near baseline pre-mining conditions. Due to exposure of the rock within the mine to air and water over the mine life, the quality of groundwater that floods the underground workings may be deteriorated. A groundwater flow particle tracking model was used to evaluate flow paths and travel times for contact water within the flooded mine workings during Post-Closure. Steady-state simulations of the groundwater flow particle-tracking indicated that in the Base Case and Uppermost Case scenarios, most of the contact water will eventually discharge into Murray River along its reach closest to the mine. The travel time of contact water varies depending on the distance from the river. The shortest estimated travel times are for the groundwater that contacts the post-mine voids on the eastern edge of the mine Block No. 1 – the area closest to the river. The calculated times are 1,000 and 400 years for the Base Case and the Uppermost Case (higher permeability case), respectively.

A small portion of contact water - from the northwestern edges of the mine Blocks No. 3 and 4 - could potentially discharge into Wolverine River. The model calculated travel times for these pathlines are measured in tens of thousands of years.

By accounting for the time of the mine flooding and the water table recovery, the calculated minimum times are about 1,200 years and 460 years in the Base Case and the Uppermost Case, respectively.

Over such a long period of travel time, it is expected that the mine contact water will be diluted by the fresh groundwater in the formations along the flow paths toward the rivers, and that the effect of the mine would not be distinguishable from background groundwater when discharging to the rivers at Post-Closure.

Therefore, residents of Tumbler Ridge and workers from other adjacent infrastructure and activities (e.g., oil and gas wells, forestry, pipelines, turbines) are unlikely to be affected by groundwater quality (as a drinking water source) because no exposure pathway exists (i.e., it is assumed that these potential receptors obtain their drinking water from regulated water systems while at home or at work, and water quality in existing wells in the area is not predicted to be different than background conditions).

18.7.2 Mitigation Measures for Human Health Effects from Drinking Water Quality

Mitigation to reduce effects to human health from ingestion of drinking water relies on mitigation measures that reduce the potential for effects to water 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 8, Section 8.7.4 of this Application/EIS. These mitigation measures include:

- 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 Coal Preparation Plant to minimise water discharged to the environment. Details can be found in the Water Management Plan (Chapter 24.6);

- CCR piles will be constructed on a geomembrane liner to minimize infiltration of contact water to groundwater. Water that does infiltrate will be captured in a seepage collection system that will drain contact water into a collection sump. This water will be preferentially reclaimed and pumped to the Coal Preparation Plant, and excess water will be pumped into the CPP pond. After reclamation, surface runoff is rerouted to M19A Creek, and infiltrated water will be recharged to groundwater through exfiltration galleries;
- The Erosion and Sediment Control Plan (Chapter 24.5) will minimize the potential for Project-related introduction of total suspended solids into surface water;
- The Metal Leaching and Acid Rock Drainage Plan (Chapter 24.7) will ensure that handling of materials will minimize the potential for metal mobilization into the aquatic environment;
- The Air Quality Management and Monitoring Plan includes measures to reduce vehicle emissions and minimizes the potential for exhaust by-products to enter the aquatic environment; and
- 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* and Drinking Water Protection Regulation.

In addition to the above mitigation measures, general access to the mine site will be controlled, limiting the likelihood of exposure to a potential human health risk associated with Project effluent during the practise of traditional and/or recreational activities within the Project area.

18.7.3 Key Effects on Human Health from Air Quality

Human receptors for the air quality human health assessment are people that reside in or temporarily occupy the LSA, such as people visiting the hunting and trapping cabins; transient or recreational land users who may fish, hunt, or collect berries and other plants in the Project area; people residing in Tumbler Ridge; and workers at other adjacent infrastructure and activity sites.

Direct exposure pathways exist from the sources of air emissions, such as fuel combustion exhaust from generators, equipment and machinery, vehicles, and helicopters, or dust from disturbance of the access road and other disturbances of the waste rock and ore to human receptors through the inhalation pathway (Figure 18.7-1).

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 difficulty breathing, wheezing, coughing, and aggravation of existing respiratory and cardiac conditions. Individual reactions depend on the type of 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 2009).

The following is a list of major air pollutants that were identified in the AIR (BC EAO 2014) as indicators, which were modelled for the Operation phase of the Project (Chapter 6) and their potential human health effects at elevated concentrations:

- NOx: Exposure to elevated levels can decrease lung function and lung function growth in children, irritate the respiratory system, and make breathing difficult (Health Canada 2013).
- SO_2: Exposure to elevated levels can increased breathing resistance, wheezing, shortness of breath, coughing, sore throat; SO_2 can cause breathing problems in people with asthma.
- Airborne particles: TSP and fine particles (i.e., $PM_{2.5}$ and PM_{10}) may pose a risk to human health as they can travel into and lodge themselves deeply in the lungs, depending on size. $PM_{2.5}$ 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.
- CO: CO can decrease athletic performance and aggravate cardiac symptoms or cause flu-like symptoms: headache, fatigue, nausea, vomiting, increased heart rate, impaired mental and cognitive function.

The only contributor of VOC emissions from the Project is from fuel combustion exhaust and a short section of natural gas pipeline for coal drying and boilers. Based on experience from other projects and professional knowledge, VOC emissions are expected to be minimal and were scoped out of the assessment. Therefore, VOC emissions were not included in the dispersion model and the AIR does not require their assessment (see Chapter 6, Appendix 6-B, Section 2.4).

Among the CACs, only $PM_{2.5}$ is recognised 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. WHO (2013) also recognizes the carcinogenic properties of particulate matter. However, neither Health Canada nor the US EPA have provided a quantitative estimate of carcinogenic inhalation risk (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.

18.7.4 Mitigation Measures for Human Health Effects from Air Quality

Mitigation measures for air quality were described in Chapter 6 of the Application/EIS and in the Air Quality and Dust Control Management Plan (Chapter 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. The Project has been designed to reduce adverse effects by optimizing alternatives, incorporating specific design changes, following best practices, and enhancing project benefits.

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, roads, and storage piles, installing covers on equipment and loads carried by vehicles, installing windbreaks or fences, using dust hoods and shields, and instituting speed control along unpaved (and other) roads. Further details can be found in the Air Quality and Dust Control Management Plan (Chapter 24.2).

18.7.5 Key Effects on Human Health from Quality of Country Foods

The purpose of the country foods effects assessment was 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 coal mine located in a mineralized area, the emphasis in the assessment is on metals since these are the most likely contaminants to be present in the aquatic or terrestrial environment at levels high enough to have the potential to affect human health (via country foods consumption) in the LSA or RSA. The rationale for this evaluation was that people could use the LSA for obtaining food from hunting, trapping, fishing, and berry picking. People may stay at the hunting and trapping cabins, Lions campground, near Murray River, and the Core Lodge.

There are no permanent residents living in the country foods LSA; however, seasonal and temporary use of the area does occur (described in Chapter 18, Section 18.6.2; Appendix A of Appendix 18-A; Chapter 15; Chapter 16; Chapter 17; and Chapter 20; The Firelight Group 2014). Aboriginal hunters, trappers, and gatherers are likely the most frequent users of the country foods LSA and are therefore the focus of the assessment (Health Canada 2010e).

An assessment of the quantity and accessibility of country foods is not provided, because the assessment focuses on country foods quality and potential impacts to human health due to incidental intake of contaminants present in the country foods. An assessment of potential loss and degradation of ecosystems is provided in Chapter 11. Loss or alteration of wildlife habitat is assessed in Chapter 13.

The following sections provide a brief description of the potential for Project-related changes in the quality of country foods that may occur due air emissions or changes in freshwater quality, and the subsequent potential health effects to humans from the ingestion of metals in country foods.

<u>Potential for Change in the Quality of Country Foods due to Contaminants in Air Emissions</u>

A variety of Project components such as the access roads, mine ventilation, waste rock and ore handling facilities, and the variety of equipment (e.g., generators, graders, dozers) and transportation methods (e.g., vehicles and rail) can result in emissions of airborne pollutants (e.g., particulate matter, combustion by-products) and fugitive dust. This may occur during all phases of the Project. Atmospheric Project emissions have the potential to enter the air and be transported to some distance from the source. The contaminants in air emissions have the potential to affect country foods directly (e.g., through inhalation of contaminants by wildlife) or indirectly (e.g., through the food chain via consumption of soil and vegetation).

While it is possible that country foods (e.g., moose and other terrestrial organisms) could take up contaminants from inhalation of contaminants from air, this pathway is considered to be a very minor source of contaminants compared to uptake through the diet (Sample et al. 1997; BC MOE 2013f). Therefore, exposure of country foods to contaminants via the inhalation route has been excluded from further consideration in wildlife harvested as country foods.

The main source of Project-related contaminant release to the terrestrial environment is through deposition of dust (Figure 18.7-1). Fugitive dust containing metals from a variety of sources could result in metal deposition to soils within the country foods LSA. The metals in soil can be taken up by wildlife through incidental intake of soil while eating vegetation. Metals in soil can also be taken up by vegetation through the roots, and fugitive dust containing metals may be deposited directly on the surface of vegetation. Metals in soil or vegetation can enter the human food chain when consumed by organisms (e.g., wildlife) that are collected or harvested as country foods. Berries, with fugitive dust present on their external surfaces, could be directly consumed by human receptors.

Potential for Change in the Quality of Country Foods due to Contaminants in Freshwater

There are several potential sources of contaminants to the freshwater environment, which are described in more detail in Section 18.7.1 and Chapter 8. Water that has been in contact with Project infrastructure has the potential to contain contaminants such as metals. Terrestrial or aquatic organisms that are consumed as country foods could take up these contaminants from the water, which could affect the quality of country foods (Figure 18.7-1).

Human Health Effects due to Country Foods Quality

Toxicity 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 childbearing 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 spends in the area.

18.7.6 Mitigation Measures for Human Health Effects from Quality of Country Foods

Mitigation measures proposed to protect environmental quality (i.e., air quality 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 Section 18.7.4, Chapter 6, and Chapter 24, Section 24.2. Mitigation measures for surface water quality were discussed in Chapter 8 and Section 18.7.2. A selenium management plan (Section 24.10) has also been developed to address potential issues with elevated selenium in some receiving environments, including mitigation measures and monitoring in the aquatic receiving environment.

These mitigation and management measures include using relevant Best Management Practices, sediment and erosion control, contaminant loading mitigation and management measures, discharge mitigation and management measures, and routine inspection and monitoring.

The Wildlife Management Plan (Chapter 24.12) includes monitoring and mitigation measures to address wildlife exposure to standing and contaminated water, such as water storage/sedimentation ponds located onsite. These mitigation measures will minimize the potential for wildlife exposure to water containing metals or other contaminants, which will minimize the potential for uptake of contaminants by animals that may be hunted as country foods.

Public access will be restricted along onsite roads through the Site Access Management Plan (Chapter 24, Section 24.17). In addition, a no hunting and gathering policy will be implemented for workers while present on-site, 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).

18.7.7 Key Effects on Human Health from Noise

Noise can directly affect human health through psychological and physiological effects. There are three main ways that noise can adversely affect humans: through sleep disturbance, activity interference such as a reduction in speech intelligibility, or increased annoyance. The measures of the potential effects of noise covered in this human health assessment are those recommended by Health Canada (2010g).

Noise guidelines can be specified based on Project noise levels or the total (baseline plus Project) noise levels. For relative criteria, that is, criteria based on the increase in noise from existing conditions, total noise has been used. For an absolute criterion, that is 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 (Appendix 18-C).

Health Canada (2010g) 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).

18.7.7.1 Sleep Disturbance

Uninterrupted sleep is required for normal physiological and mental functioning; however, environmental noise commonly causes sleep disturbance (WHO 1999). The primary effects of sleep disturbance are: 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). 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 60 dB (L_{max}) 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, so the vast majority of the population would not suffer sleep disturbance above guidelines. Vehicle pass-by can contribute to sleep disturbance and therefore was included as a source in the assessment.

Due to the proximity of the community of Tumbler Ridge, mine workers will not be sleeping on-site. Thus the evaluation of sleep disturbance is only required for human receptors off-site. Some of the off-site receptors are campgrounds, to which the indoor sound attenuation (including having windows open or closed) will not apply. 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.

18.7.7.2 Interference with Speech Communication

Speech interference occurs when noise levels are high enough that the ability to understand speech is impaired (WHO 1999). Normal speech has a sound pressure level of approximately 55-58 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 for continuous noise (US EPA 1974). Vehicle pass-by can contribute to speech interference and therefore was included as a source in the assessment. Project-related noise interference with speech communication were assessed for non-workers within the Noise RSA.

Workers from adjacent infrastructure and activities (e.g., workers at Tumbler Ridge Wind Energy) have been considered as potential human receptors to be assessed (Health Canada 2010g). Due to the proximity of these projects to the city of Tumbler Ridge, workers are likely to live and sleep at accommodations in town. 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); therefore occupational noise limit of 85 dBA (L_{ex}) was used to assess daytime Project-related noise effects to workers form adjacent projects (BC Reg. 296/97). In addition, working hours for workers from adjacent Projects (e.g., Tumbler Ridge Wind Energy Project) may vary and may include night shifts. Therefore, L_{ex} criteria were also compared to the predicted nighttime noise levels as well.

18.7.7.3 High 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, etc.); absolute level of sound; time of day; local attitudes to the Project; and expectations for quiet.

The percent highly annoyed (% HA) metric is a reliable and widely accepted indicator of human health effects due to environmental noise and is calculated using the adjusted L_{dn} (or rating level) pre- and post-Project (Michaud, Bly, and Keith 2008; Health Canada 2010g). Much of the data available on the health and welfare effects of noise are expressed in terms of % HA, yet this is a description of a subjective human reaction to "noise interference" (US EPA 1974). While the % HA can be statistically quantified, it is not a legal concept and it is the actual interference with activity that is important (US EPA 1974). However, the change in % HA within an average community in reaction to sound levels has been reported as uniform (Michaud, Bly, and Keith 2008). Health Canada (Health Canada 2010g) advises that when there is a change in the % HA by a population (at a specific receptor location) greater than 6.5%, or if the Project L_{dn} exceeds 75 dBA, then noise mitigation measures should be considered.

Adjustments to sound levels are suggested to account for more annoying sound characteristics such as the presence of tonal or impulsive noise (US EPA 1974). The penalty for tones and regular impulsive sound is a +5 dBA adjustment which is added to the predicted, calculated, or measured sound pressure level (US EPA 1974). The penalty for highly impulsive noise is a +12 dBA adjustment. The penalties for high-energy impulsive sound and sound with strong low frequency content are variable and calculated according to the American National Standards Institute (ANSI) standard S12.9-2005/Part 4 (ANSI 2005). The penalty for sound with strong low frequency content should only be considered if the C-weighted sound pressure level is more than 10 dB higher than the A-weighted sound pressure level.

Employees from the Project and from other adjacent projects need not be included in the annoyance assessment as it applies to communities and not workers at project sites.

18.7.7.4 Noise Induced Hearing Loss (NIHL)

NIHL concerns are normally most efficiently addressed in the Project detailed design phase due to the high variation in actual occupational noise exposures depending on design details. Therefore, the potential for NIHL has not been included in this assessment.

18.7.8 Mitigation Measures for Human Health Effects from Noise

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 (Chapter 24, Section 24.3) has been developed to provide measures to control the noise sources (i.e., to reduce the overall noise from the Project). In addition, a monitoring program will be undertaken to make sure that noise levels propagated from the Project will meet relevant human health and wildlife standards and guidelines (Chapter 24, Section 24.3). Periodic noise monitoring will be performed to assess noise levels at sensitive receptor locations and should include monitoring of overnight noise, instantaneous noise, vehicle pass-by noise, and interior noise levels at production facilities. The mitigation measures are considered reasonable to manage and monitor noise from the Project.

18.8 RESIDUAL EFFECTS ON HUMAN HEALTH

This section will describe the methods and results of the effects assessment for each VC. The purpose of an Environmental Assessment under the *Canadian Environmental Assessment Act* (1992) is to evaluate the potential for a project to cause environmental effects, including any effect of the changes in the environment on human health. The Health Canada (2010f) document *How Health Canada Contributes to Environmental Assessment* states, "EA is designed to anticipate and prevent adverse effects of projects. Simply put, EA involves determining any changes or impacts that a project or action will have on our surroundings – be it positive or negative effects – before that project is carried out in order to prevent irrevocable damage from occurring." Thus the focus is on Project-related effects, not on the effects that may already be present prior to the development of a proposed project.

This is a critical difference between conducting a human health risk assessment (HHRA) based on existing conditions (e.g., at a contaminated site) and conducting a HHRA in the context of an environmental assessment to assess Project-related effects. Within the context of an environmental assessment, it is important to take into consideration existing baseline conditions so that only changes in the environment due to the Project are identified and carried forward into the assessment of residual effects. The methodology for identifying Project-related COPCs for consideration in the residual effects assessment (described in Sections 18.8.1.1, 18.8.2.1, and 18.8.3.1) explicitly considers existing baseline conditions to ensure that only potential effects due to the Project are included in the assessment of residual effects to human health.

The federal EIS Guidelines for the Project identify that "when risks to human health due to changes in one or more of these [biophysical] components are predicted, a complete Human Health Risk Assessment (HHRA) examining all exposure pathways for pollutants of concern may be necessary to adequately characterize potential risks to human health." The selection procedures for Project-related COPCs described in Sections 18.8.1.1 (for drinking water quality), 18.8.2.1 (for air quality), and 18.8.3.1 (for country foods quality) are intended to identify Project-related changes in the quality of the biophysical environment that have the potential to affect human health.

If the selection procedure identifies any COPCs based on predictive modelling of the biophysical environment, these will be carried forward into a HHRA as recommended by the federal EIS Guidelines for the Project. If no COPCs are identified (i.e., there is either no change in the biophysical environment or the change in the biophysical environment does not have the potential to affect human health), no HHRA is required and no residual effects to human health due to the Project would be predicted.

18.8.1 Residual Effects on Human Health from Drinking Water Quality

18.8.1.1 Methodology for Identifying Contaminants of Potential Concern in Drinking Water

To assess residual effects to human health from changes in drinking water quality due to Project-related activities, future surface water quality was modeled. The methodology and assumptions used in the water quality model and the results are described in described in Chapter 8 and Appendix 8-E. Water quality modelling provided quantitative estimates of predicted surface water quality at several modelling nodes located in the receiving environment 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 18.5), predicted surface water quality at the modelling nodes located within the LSA was compared to British Columbia (BC MOE 2013g) and Canadian DWQGs (Health Canada 2012a). In cases where BC DWQGs were absent for a parameter, the Canadian DWQGs were used if available.

Hazard quotients (HQs) were calculated by dividing the predicted concentrations of metals by the applicable DWQG limits at each of the modelling nodes (Chapter 8, Section 8.8.1 and Appendix 8-G). If a metal was found to have a HQ less than 1.0 (relative to the guideline) for a particular modelling node, it would be screened out of the HHRA for that specific location, since these metals 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 screening step, the predicted median and maximum water concentration would be compared to the baseline median and 95th percentile water concentrations, respectively. This step is done to ensure that all COPCs identified and carried through the HHRA process are only those with concentrations that were predicted to have an increase beyond baseline levels due to Project-related activities. This process eliminates COPCs with concentrations that already exceeded guidelines during the baseline studies (which is not a Project-related effect) and are not predicted to have a further measurable increase.

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 carried forward in the HHRA for further evaluation.

18.8.1.2 Contaminants of Potential Concern in Drinking Water

Screening for COPCs based on water quality model results was completed in Chapter 8, Section 8.8.1, with detailed results shown in Appendix 8-G.

As seen in Chapter 8, Appendix 8-G, all predicted metal concentrations at the water quality modelling nodes were below the BC or CCME DWQGs, thus all the HQs were below 1.0. For sites that were not modelled, the concentrations of metals were assumed to be either the same as baseline concentrations or below BC or CCME DWQGs.

No COPCs were identified in the drinking water assessment and no human health risks due to ingestion of surface water were identified. No residual effects on human health due to drinking water quality were identified through this predictive, quantitative screening level risk assessment. As a result, human health effects due to drinking water will not be considered further.

18.8.2 Residual Effects on Human Health from Air Quality

18.8.2.1 Methodology for Identifying Contaminants of Potential Concern in Air

To assess residual effects to human health from changes in air quality due to Project-related emissions, future Project-related air quality was modeled. The methodology and assumptions used in the air quality dispersion model and the results are described in Chapter 6, Appendix 6-A. A screening process was used to select COPCs for human health due to predicted air quality changes throughout the LSA and also at specific identified human receptor locations during the Operation phase. The screening process for criteria air pollutants is shown in flowchart in Figure 18.8-1.

The air quality model provided predictions for:

- 1-hour, 24-hour, and annual averaging period concentrations for SO_2, NO_2, CO;
- 24-hour averaging period concentrations for PM_{10}; and
- 24-hour and annual averaging period concentrations for TSP and $PM_{2.5}$.

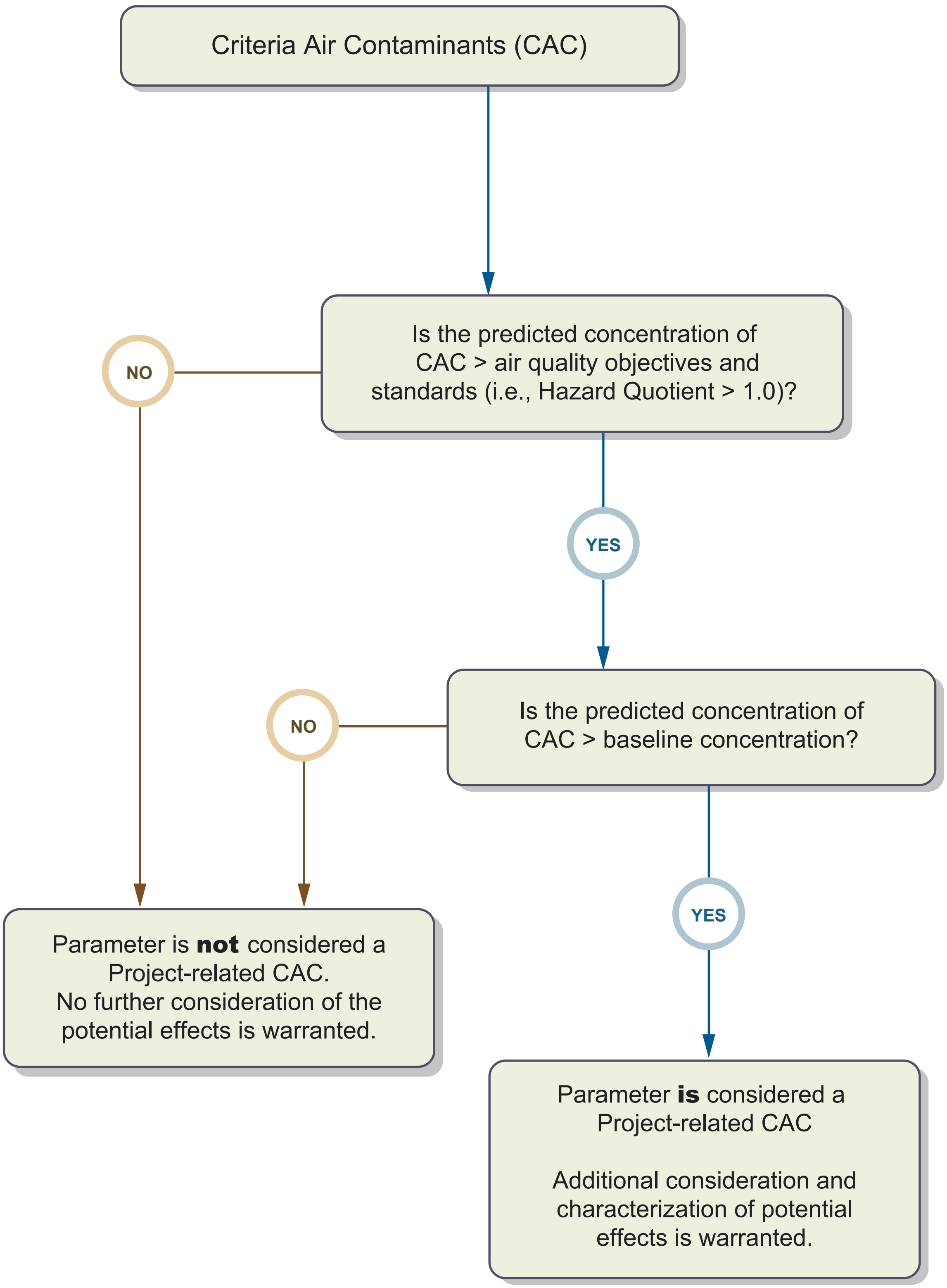
The model predictions were compared to federal (CCME 1999a; Environment Canada 2013a) and provincial (BC MOE 2013a) ambient air quality criteria or objectives in order to identify COPCs. Provincial (BC MOE) ambient air quality criteria were used preferentially for consistency with screening procedures.

Hazard quotients (HQs) were calculated by dividing the predicted concentrations of CACs by guideline limits at each human receptor location (Table 18.8-1). If a CAC was found to have a HQ less than 1.0 for a particular receptor point, it would be screened out of the HHRA for that specific receptor location, since the CAC would not be expected to cause adverse health effects at that receptor location.

If a CAC was found to have a HQ greater than 1.0 relative to the guideline limit at a particular receptor location, the CAC would be retained for a second screening step. In the second screening step, the predicted CAC concentration would be compared to the baseline concentrations. This step was done to ensure that all CACs identified and carried through the HHRA process for each receptor location were only those with concentrations that were predicted to have a measureable increase beyond baseline levels due to Project-related activities. This process eliminates CACs for receptor locations which already exceeded guidelines during the baseline studies (which is not a Project-related effect).

If a predicted CAC was greater than both the baseline concentration and the guideline limit, then it would be identified as a COPC and would be carried forward in the HHRA for further evaluation at that particular receptor point.

Screening Process for Selection of Criteria Air Contaminants for Air Quality Effects Assessment



18.8.2.2 Criteria Air Contaminants of Concern

In Chapter 6 (Table 6.7-1 and Section 6.7.1.1), it is noted that the maximum 24-hour concentrations of two parameters exceed the guidelines in some areas along the road including:

- Maximum 24-hour predicted TSP concentrations exceed the objectives outside of the mine site 8.2% of the time within 1.3 km of the road; the exceedances were from fugitive sources, primarily from road dust.
- Maximum 24-hour predicted PM_{10} concentrations exceed the objectives outside of the mine site 2.7% of the time within 0.5 km of the road; the exceedances were from fugitive sources, primarily from road dust.

The air quality dispersion model has been run assuming no anthropogenic dust control. Proposed mitigation measures such as road watering would substantially reduce the amount of unpaved road dust, but are not accounted for in the model. This produces predicted concentrations that are conservative and likely overestimates the potential concentrations of TSP and PM_{10}.

The effects assessment for air quality conducted in Chapter 6 (Section 6.9.1) concluded that the effects would be not significant (moderate). No known human health receptor locations occur in this area. Although it is possible that a person may pass through the area or use the road, 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 concentrations are high. Thus, the potential exposure time at this location is 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 area; therefore, these exceedances are not considered further in this chapter.

For air quality predictions at specific human receptor locations, the results of the CAC screening process for the Operation phase are shown in Table 18.8-1. Concentrations of CACs were modelled for the human health receptor sites, as shown on Figure 18.6-4. Predicted CAC concentrations (NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$) at all 18 human health receptor locations modelled were below federal and provincial ambient air quality criteria, with HQs less than one. No risks to human health were identified for any CACs during the Operation phase of the Project; therefore, no residual effects on human health due to air quality was identified at the known human receptor locations. As a result, human health effects due to air quality will not be considered further.

18.8.3 Residual Effects on Human Health from Quality of Country Foods

18.8.3.1 Methodology for Identifying Contaminants of Potential Concern in Country Foods

A screening process was used to select COPCs in country foods based on their potential to affect human health. Metals were the primary type of contaminants considered since other chemicals are unlikely to be present as a result of Project activities at high enough concentrations to lead to effects on human health, after mitigation and management measures are taken into consideration (Section 18.7.6).

Table 18.8-1. Summary of Baseline and Model Predictions of Criteria Air Pollutants at Human Health Receptor Locations during Operation

Criteria Air Pollutant		Averaging Period	British Columbia Ambient Air Quality Objectives[1] (µg/m^3)	National Ambient Air Quality Objectives - Maximum Desirable[2, 3] (µg/m^3)	Trapline Cabin 6				Quintette Coal Mine (Windy Pit)				Quintette Coal Loadout				Trapline Cabin 5			
					Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?
SO_2		1-hour	450	450	0.394	No	0.000876	No	0.721	No	0.00160	No	2.15	No	0.00478	No	2.75	No	0.00611	No
		24-hour	160	150	0.0676	No	0.000423	No	0.157	No	0.000981	No	0.409	No	0.00256	No	0.330	No	0.00206	No
		Annual	25	30	0.00783	No	0.000313	No	0.0157	No	0.00063	No	0.0411	No	0.00164	No	0.0258	No	0.0010	No
NO_2		1-hour	400	-	0.588	No	0.00147	No	4.76	No	0.0119	No	9.28	No	0.0232	No	4.86	No	0.0122	No
		24-hour	200	-	0.169	No	0.00085	No	1.37	No	0.00685	No	2.75	No	0.0138	No	1.26	No	0.00630	No
		Annual	60	-	0.0155	No	0.000258	No	0.113	No	0.001883	No	0.760	No	0.0127	No	0.176	No	0.00293	No
CO		1-hour	14,300	15,000	235	No	0.0164	No	237	No	0.0166	No	244	No	0.0171	No	247	No	0.0173	No
		8-hour	5,500	6,000	233	No	0.0424	No	234	No	0.0426	No	237	No	0.0431	No	238	No	0.0432	No
Total (fugitive + non-fugitive)	TSP	24-hour	120	-	46.1	No	0.384	No	84.3	No	0.703	No	119	No	0.992	No	64.6	No	0.538	No
		Annual	60	-	12.6	No	0.209	No	13.5	No	0.225	No	24.8	No	0.413	No	13.8	No	0.231	No
	PM_{10}	24-hour	50	-	21.7	No	0.433	No	32.1	No	0.641	No	40.6	No	0.813	No	26.4	No	0.529	No
	$PM_{2.5}$	24-hour	25	27	11.0	No	0.438	No	11.5	No	0.460	No	12.5	No	0.501	No	11.3	No	0.451	No
		Annual	8	8.8	3.31	No	0.414	No	3.37	No	0.421	No	3.77	No	0.471	No	3.37	No	0.421	No

Criteria Air Pollutant		Averaging Period	British Columbia Ambient Air Quality Objectives[1] (µg/m^3)	National Ambient Air Quality Objectives - Maximum Desirable[2, 3] (µg/m^3)	Trend Mine Washing Plant and Coal Loadout				Facility Near Loadout				Tumbler Ridge Wind Energy Project				Trapline Cabin 4			
					Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?
SO_2		1-hour	450	450	4.34	No	0.00964	No	3.67	No	0.00816	No	1.80	No	0.00400	No	1.45	No	0.00322	No
		24-hour	160	150	0.770	No	0.00481	No	1.17	No	0.00731	No	0.393	No	0.00246	No	0.290	No	0.00181	No
		Annual	25	30	0.112	No	0.00448	No	0.111	No	0.00444	No	0.0299	No	0.00120	No	0.0390	No	0.00156	No
NO_2		1-hour	400	-	17.2	No	0.0429	No	13.5	No	0.034	No	3.60	No	0.0090	No	1.49	No	0.00373	No
		24-hour	200	-	6.16	No	0.0308	No	4.22	No	0.0211	No	0.869	No	0.00435	No	0.306	No	0.00153	No
		Annual	60	-	1.56	No	0.0260	No	1.00	No	0.0167	No	0.0755	No	0.00126	No	0.0648	No	0.00108	No
CO		1-hour	14,300	15,000	256	No	0.0179	No	253	No	0.0177	No	242	No	0.0169	No	241	No	0.0169	No
		8-hour	5,500	6,000	245	No	0.0446	No	245	No	0.0446	No	236	No	0.0429	No	236	No	0.0429	No
Total (fugitive + non-fugitive)	TSP	24-hour	120	-	97.6	No	0.813	No	86.3	No	0.719	No	60.9	No	0.507	No	46.7	No	0.389	No
		Annual	60	-	22.7	No	0.378	No	19.1	No	0.318	No	12.9	No	0.216	No	12.7	No	0.212	No
	PM_{10}	24-hour	50	-	43.0	No	0.860	No	39.4	No	0.788	No	25.7	No	0.514	No	21.9	No	0.437	No
	$PM_{2.5}$	24-hour	25	27	14.8	No	0.592	No	14.6	No	0.586	No	11.2	No	0.449	No	11.1	No	0.442	No
		Annual	8	8.8	4.12	No	0.515	No	3.93	No	0.491	No	3.35	No	0.419	No	3.33	No	0.416	No

Criteria Air Pollutant		Averaging Period	British Columbia Ambient Air Quality Objectives[1] (µg/m^3)	National Ambient Air Quality Objectives - Maximum Desirable[2, 3] (µg/m^3)	Lions Campground				Tumbler Ridge Health Centre				Hunting Cabin 21				Quality Wind Project			
					Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (µg/m^3)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?
SO_2		1-hour	450	450	1.10	No	0.00244	No	1.28	No	0.00284	No	0.446	No	0.00099	No	1.22	No	0.00271	No
		24-hour	160	150	0.194	No	0.00121	No	0.204	No	0.00128	No	0.0691	No	0.000432	No	0.346	No	0.00216	No
		Annual	25	30	0.0228	No	0.000912	No	0.0236	No	0.000944	No	0.0101	No	0.000404	No	0.0573	No	0.00229	No
NO_2		1-hour	400	-	1.05	No	0.00263	No	1.21	No	0.00303	No	1.13	No	0.00283	No	3.97	No	0.0099	No
		24-hour	200	-	0.205	No	0.00103	No	0.353	No	0.00177	No	0.290	No	0.00145	No	0.831	No	0.00416	No
		Annual	60	-	0.0389	No	0.000648	No	0.0526	No	0.000877	No	0.0214	No	0.000357	No	0.143	No	0.00238	No
CO		1-hour	14,300	15,000	239	No	0.0167	No	240	No	0.0168	No	235	No	0.0164	No	240	No	0.0168	No
		8-hour	5,500	6,000	235	No	0.0427	No	235	No	0.0428	No	233	No	0.0424	No	236	No	0.0428	No
Total (fugitive + non-fugitive)	TSP	24-hour	120	-	47.3	No	0.394	No	47.7	No	0.398	No	46.5	No	0.387	No	54.8	No	0.457	No
		Annual	60	-	12.7	No	0.211	No	12.7	No	0.212	No	12.6	No	0.210	No	13.3	No	0.221	No
	PM_{10}	24-hour	50	-	22.0	No	0.439	No	22.1	No	0.441	No	21.7	No	0.435	No	24.4	No	0.488	No
	$PM_{2.5}$	24-hour	25	27	11.0	No	0.440	No	11.0	No	0.440	No	11.0	No	0.439	No	11.5	No	0.460	No
		Annual	8	8.8	3.32	No	0.415	No	3.33	No	0.416	No	3.31	No	0.414	No	3.39	No	0.424	No

(continued)

Table 18.8-1. Summary of Baseline and Model Predictions of Criteria Air Pollutants at Human Health Receptor Locations during Operation (completed)

Criteria Air Pollutant		Averaging Period	British Columbia Ambient Air Quality Objectives[1] (μg/m³)	National Ambient Air Quality Objectives - Maximum Desirable[2, 3] (μg/m³)	Trapline Cabin 9				Babcock Creek Wind Project				Hermann Mine Project				Trapline Cabin 7			
					Predicted Air Concentration (μg/m³)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (μg/m³)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (μg/m³)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (μg/m³)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?
SO_2		1-hour	450	450	1.07	No	0.00238	No	1.58	No	0.00351	No	1.11	No	0.00247	No	0.246	No	0.000547	No
		24-hour	160	150	0.240	No	0.00150	No	0.232	No	0.00145	No	0.233	No	0.00146	No	0.0498	No	0.000311	No
		Annual	25	30	0.0325	No	0.00130	No	0.0474	No	0.00190	No	0.0311	No	0.00124	No	0.00572	No	0.000229	No
NO_2		1-hour	400	-	3.56	No	0.0089	No	7.17	No	0.0179	No	4.08	No	0.0102	No	1.11	No	0.00278	No
		24-hour	200	-	0.994	No	0.00497	No	1.68	No	0.0084	No	0.948	No	0.00474	No	0.291	No	0.00146	No
		Annual	60	-	0.188	No	0.00313	No	0.475	No	0.0079	No	0.0942	No	0.00157	No	0.0192	No	0.000320	No
CO		1-hour	14,300	15,000	239	No	0.0167	No	245	No	0.0171	No	238	No	0.0167	No	234	No	0.0163	No
		8-hour	5,500	6,000	235	No	0.0428	No	237	No	0.0430	No	234	No	0.0426	No	233	No	0.0423	No
Total (fugitive + non-fugitive)	TSP	24-hour	120	-	52.7	No	0.439	No	77.4	No	0.645	No	58.3	No	0.486	No	47.1	No	0.392	No
		Annual	60	-	13.7	No	0.228	No	17.4	No	0.291	No	13.0	No	0.217	No	12.6	No	0.209	No
	PM_{10}	24-hour	50	-	24.0	No	0.481	No	30.4	No	0.608	No	25.1	No	0.501	No	21.9	No	0.438	No
	$PM_{2.5}$	24-hour	25	27	11.6	No	0.465	No	11.8	No	0.470	No	11.2	No	0.449	No	11.0	No	0.438	No
		Annual	8	8.8	3.42	No	0.428	No	3.58	No	0.448	No	3.35	No	0.419	No	3.31	No	0.414	No

Criteria Air Pollutant		Averaging Period	British Columbia Ambient Air Quality Objectives[1] (μg/m³)	National Ambient Air Quality Objectives - Maximum Desirable[2, 3] (μg/m³)	Core Lodge				Trend Coal Mine			
					Predicted Air Concentration (μg/m³)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?	Predicted Air Concentration (μg/m³)	Predicted > Guideline?	Hazard Quotient for Guideline	Selected as a COPC?
SO_2		1-hour	450	450	0.381	No	0.000847	No	0.368	No	0.000818	No
		24-hour	160	150	0.0779	No	0.000487	No	0.0836	No	0.000523	No
		Annual	25	30	0.00768	No	0.000307	No	0.00748	No	0.000299	No
NO_2		1-hour	400	-	2.38	No	0.0060	No	2.66	No	0.0067	No
		24-hour	200	-	0.874	No	0.00437	No	1.06	No	0.0053	No
		Annual	60	-	0.0451	No	0.00075	No	0.0454	No	0.00076	No
CO		1-hour	14,300	15,000	235	No	0.0164	No	236	No	0.0165	No
		8-hour	5,500	6,000	234	No	0.0425	No	235	No	0.0426	No
Total (fugitive + non-fugitive)	TSP	24-hour	120	-	59.4	No	0.495	No	57.9	No	0.482	No
		Annual	60	-	12.8	No	0.214	No	12.9	No	0.214	No
	PM_{10}	24-hour	50	-	25.3	No	0.506	No	24.8	No	0.497	No
	$PM_{2.5}$	24-hour	25	27	11.2	No	0.446	No	11.2	No	0.449	No
		Annual	8	8.8	3.33	No	0.416	No	3.33	No	0.416	No

Notes:

[1] *BC MOE (2013).*

[2] *Environment Canada (2013). Backgrounder: Canadian Ambient Air Quality Standards. (For $PM_{2.5}$ coming into effect in 2020).*

[3] *CCME (1999). Objectives for CO.*

CO = carbon monoxide

COPC = contaminant of potential concern

Baseline concentrations of TSP were determined from a typical ratio from PM_{10} using the AP-42 aerodynamic particle size multiplier for aggregate handling.

NO_2 = nitrogen dioxide

TSP = total suspended particles

SO_2 = sulphur dioxide

Baseline concentrations of PM_{10} and $PM_{2.5}$ are the 98th percentile for 24-hour concentrations and average concentrations for annual concentrations derived from samples taken from the PM monitor located at the Tumbler Ridge Airport since 2006.

$PM_{2.5}$ = particulate matter up to 2.5 μm in size

PM_{10} = particulate matter up to 10 μm in size

Concentration used for calculating chronic exposure dose is the predicted maximum concentration for 24-hour averaging.

BC MOE (2013) ambient air quality criteria were used preferentially for consistency with screening procedures.

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 as a result of deposition of dust containing metals or effluent discharge containing metals. Because country foods can take up metals from environmental media (i.e., water, soil, and vegetation), the quality of the foods is directly influenced by concentrations of contaminants in the media. To determine the potential effects to country foods, a screening process was developed for selection of COPCs based on predicted concentrations of metals (Figure 18.8-2). Metal concentrations predicted by modeling were screened against three assessment criteria: applicable guidelines, baseline concentrations, and the potential to bioaccumulate in the food chain.

HQs were calculated by dividing the predicted mean concentrations of a metal by the guideline limit in each relevant media. COPCs found to have a HQ less than 1.0 were screened out of the country foods assessment since these metals would not be expected to cause adverse effects in human receptors due to consumption of country foods exposed to contaminants in the environmental media.

BC-specific guidelines were preferentially used when available, including:

- British Columbia's Water Quality Guidelines for the Protection of Aquatic Life (BC MOE 2013g)
- British Columbia's Working Water Quality Guidelines for the Protection of Aquatic life (BC MOE 2006b)

The guidelines intended to protect aquatic life were used because they are typically more stringent than the human health guidelines (e.g., for drinking water quality). Where BC guidelines were unavailable, CCME guidelines were used in the screening process. The CCME has established the following environmental quality guidelines:

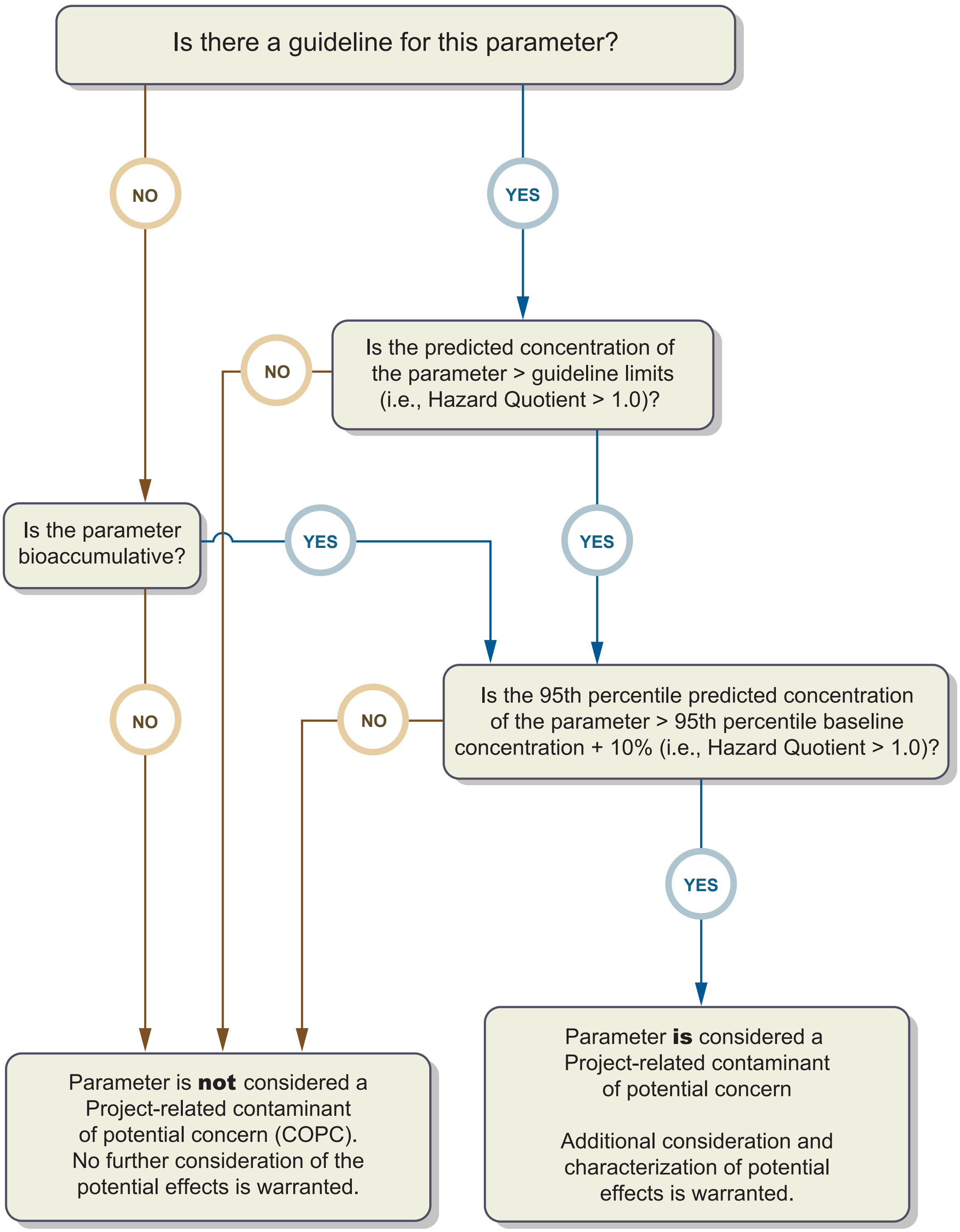
- Water Quality Guidelines for the Protection of Aquatic Life – Freshwater (CCME 2012c)
- Soil Quality Guidelines for Protection of Environmental and Human Health – Agricultural (CCME 2012b)

Note that CCME Soil Quality Guidelines for agricultural land use are considered to protect primary, secondary, and tertiary consumers from adverse effects due to ingestion of contaminated soil and food (CCME 1999b). Therefore, selection of COPCs based on vegetation quality was not done in this assessment since there are no guidelines specific to vegetation and the soil quality guidelines are considered to be protective against effects to vegetation or higher trophic level consumers.

Metals found to have a HQ greater than 1.0 relative to the guideline would be considered in a second screening step. In this step, to select COPCs for country foods via uptake through water, the median and maximum predicted water metal concentrations were compared to median and 95^{th} percentile baseline water metal concentrations (respectively, see Chapter 8, Section 8.7.1.2, and Figure 8.7-6). If the predicted median or maximum concentration of the metal was above baseline median or 95^{th} percentile concentration, the metal was considered Project-related COPCs.

Figure 18.8-2

Screening Process for Selection of Contaminants of Potential Concern for Country Foods Effects Assessment



To select COPCs for country foods via uptake through soil, a second screening was also conducted. In this step, the 95th percentile predicted soil metal concentration would be compared to the 95th percentile soil baseline metal concentration plus 10%. An increase above 10% of baseline concentration was selected because, when considering spatial variability in soil quality across the country foods LSA, field sampling variability, uncertainty in laboratory methods, and conservatism within the modelling, any contaminant concentration within 10% of baseline soil concentration is unlikely to be sufficiently distinguishable from soil background levels to be considered a Project-related effect. There was substantial variability of metal concentrations in soil samples collected during the baseline program (Chapter 10, Appendix 10-A). The second screening step was done to ensure that all country foods COPCs identified and carried through the country foods effects assessment were only those COPCs with concentrations that were predicted to increase due to Project-related activities, consistent with the goals of an environmental assessment (i.e., to identify Project-related effects).

In cases where no guidelines are available, the bioaccumulative properties of the contaminants were considered for the selection of COPCs.

At the end of the COPC selection process for each environmental medium, any metals that had:

- HQ greater than 1.0 relative to guideline **and** a HQ greater than 1.0 relative to baseline concentrations; or
- no guideline with the known potential to bioaccumulate **and** a HQ greater than 1.0 relative to baseline concentrations

the metal would be retained as a COPC for country foods to be assessed for their potential to cause health effects in human receptors. The following sections provide details of screening of country foods COPCs from each of the relevant environmental media.

<u>Selection of COPCs based on Predicted Soil Quality</u>

The pathway through which metals may enter soil as a result of Project activities is from atmospheric deposition of metals in fugitive dust. The US EPA has published methods for use in HHRA for calculating contaminant concentrations in soil due to atmospheric dust deposition (US EPA 2005). Calculations of the incremental increase in soil metal concentrations were done based on predicted metal concentrations in dustfall determined using data from the air quality dispersion model (Chapter 6) and baseline dustfall results (Chapter 6, Appendix 6-A). Air emissions are expected to be highest during the Operation phase of the Project, therefore only that phase was modelled (Chapter 6, Appendix 6-B, Section 2.3).

Air quality dispersion modelling predicted total annual dustfall for the worst-case year (i.e., the year with the highest anticipated activities and dustfall amounts) during the Operation phase (Chapter 6). For the purpose of soil quality modeling, in addition to assumptions made in the air dispersion model (Appendix 6-B), the following assumptions were made:

- the dust deposition that was predicted by the model for the worst-case scenario year of Operation phase will occur during each of the 25 years in the Operation phase;

- all dust deposited onto soil was conservatively assumed to remain in place, and not run-off during rain events; and
- the Project-related metal proportions in dust during the Operation phase in the Project area is based on the metal composition of the materials excavated (clean coal and middlings, CCR and tailings, overburden, and waste rock). The mined tonnage of each material was converted into a percentage of total materials excavated (Table 18.8-2). This percentage was then multiplied by the median metal concentrations in each material type and then all material types were summed. This provided the metal proportion in all materials excavated (based on the tonnage of each material type mined), which could then be applied to dustfall.

Table 18.8-2. Summary of Material Excavated

Material Type	Tonnes Excavated (t)	% of Total Materials Excavated
Clean coal and middlings	102,445,000	69.9
Coarse coal rejects and tailings	43,905,000	29.9
Overburden	31,000	0.021
All waste rock	452,000	0.308
Total	146,833,000	100

Source: HD Mining, pers. comm., 24 April 2014

The CALPUFF model results for dustfall amounts were multiplied with the metal proportions in the dustfall described above to predict the metal concentrations in the dust for the Operation phase of the Project (Chapter 6, Appendix 6-B, Section 6.5). Appendix 18-D provides predicted metal concentrations associated with fugitive dust for the Operation phase of the Project.

Predicted soil metal concentrations were calculated by adding the baseline soil concentration to the incremental increase in soil metal concentration predicted using the US EPA methodology and formulas (US EPA 2005). The incremental increase in soil metal concentrations was calculated for each metal using the equation below, as suggested by US EPA (2005):

$$C_S = 100 \times \left(\frac{D}{Zs \times BD}\right) \times t_D$$

where:

Cs = Average soil concentration over exposure duration (mg COPC/kg soil)

100 = Unit conversion factor (from mg-m^2 to kg-cm^2)

D = Yearly dry deposition rate of contaminant (g COPC /m^2-year)

t_D = Time period over which deposition occurs (years)

Z_s = Soil mixing zone depth (cm)

BD = Soil bulk density (g/cm^3)

The time period (t_D) over which dust deposition may occur was assumed to be 25 years for the Operation phase. Metals deposited with fugitive dust were assumed to mix with the top 2 cm of soil (Z_s), as recommended by US EPA (2005) for untilled soils. The bulk density (BD) for soil was set at the default value of 1.5 g soil/cm^3 soil, as recommended by the US EPA (2005). Weathering and degradation were considered to only be significant for organic contaminants and not metals (US EPA 2005), thus a soil loss constant was not necessary (i.e., it was assumed that none of the metals were lost to weathering or degradation).

Appendix 18-E provides the baseline, predicted incremental change, and total soil metal concentrations for the Operation phase. Table 18.8-3 provides the results of the soil screening process for the Operation phase of the project.

During the Operation phase, predicted mean metal concentrations in soil were lower than CCME Guidelines for the Protection of Environmental and Human Health for agricultural land, except for barium, cadmium, and selenium. However, the predicted mean concentrations for these three metals were lower than the mean baseline concentration plus 10% (Table 18.8-3), with a change relative to baseline concentrations of up to 0.036%. A change in soil concentrations of less than 0.05% compared to existing background levels is not measurable and is not likely to translate into a measurable change in tissue quality in terrestrial organisms that may be consumed by humans.

The soil ingestion component of the food chain model is the driving force in uptake of COPCs in wildlife. Results of the modelling indicate that the loading of most metals to soils as a result of Project activities during the Operation phase is negligible, well within the range of natural variability, and unlikely to be detectable using current analytical methodologies. Changes in soil concentration would be expected to be smaller in other phases of the Project (e.g., Decommissioning and Reclamation, Post-Closure) compared to the Operation phase. Therefore, no COPCs were identified based on predicted soil quality during the Operation phase (or any of the Project phases) for inclusion in the country foods effects assessment.

Selection of COPCs based on Predicted Freshwater Quality

Water quality model predictions were compared to the BC WQGs for the protection of aquatic life, or to the CCME guidelines when BC guidelines were not available. When water quality was predicted to exceed the applicable guidelines, a comparison of the predicted water quality to baseline water quality at the site was also done. This second step (comparison to baseline) was important for ensuring that only parameters that are predicted to increase due to Project-related activities are identified. This second step excludes parameters that have concentrations higher than guidelines during baseline studies, since this is not a Project-related effect.

The screening procedure described here is the same as that used for COPC selection in Chapter 8, which identified selenium as the only COPC for the Project (Table 18.8-4; see also Section 8.8.1.2 and Appendix 8-G for additional details and COPC selection results). Selenium was found to be a COPC during the Decommissioning and Reclamation, and Post-Closure phases only in M19A Creek. Aside from selenium in M19A Creek, no other COPCs were identified at any other surface water modelling node.

Table 18.8-3. Selection of Contaminants of Potential Concern based on Predicted Soil Quality within the Country Foods Local Study Area

Metals	Baseline (Measured) 95th Percentile Soil Concentration[2] (mg/kg)	Predicted 95th Percentile Soil Concentration (mg/kg)	Screening Step 1: CCME Soil Guidelines[1] (mg/kg dw)	Screening Step 1: Hazard Quotient relative to Lowest Guideline	Screening Step 1: Predicted Concentration > Guideline?	Screening Step 1: Bioaccumulative	Screening Step 2: 95th Percentile Baseline Soil Concentration[2] +10% (mg/kg)	Screening Step 2: Hazard Quotient relative to 95th Percentile of Soil Baseline + 10%	Screening Step 2: Predicted Concentration > 95th Percentile Soil Baseline + 10%?	Percent Change relative to 95th Percentile Soil Baseline (%)	Retained as a COPC?
Aluminum	10760	10761	-	-	-	Low					No
Antimony	0.693	0.693	20	0.0347	No	Low					No
Arsenic	11.6	11.6	12	0.969	No	Variable	12.8	0.909	No	0.00850	No
Barium	913	913	750	1.22	Yes	Low	1004	0.909	No	0.0363	No
Beryllium	1	-	4	-	-	Low					No
Bismuth	0.100	0.103	-	-	-	Low					No
Cadmium	1.96	1.96	1.4	1.40	Yes	Moderate to high	2.16	0.909	No	0.00781	No
Calcium	27750	27752	-	-	-	Low					No
Chromium	19.5	19.5	64	0.305	No	Low					No
Cobalt	8.49	8.49	40	0.212	No	Low					No
Copper	24.1	24.1	63	0.383	No	Low					No
Iron	26580	26582	-	-	-	Low					No
Lead	12.7	12.7	70	0.181	No	Low to high (plants)	14.0	0.909	No	0.0260	No
Lithium	13	-	-	-	-	Low					No
Magnesium	8097	8098	-	-	-	Low					No
Manganese	748	748	-	-	-	Low					No
Mercury	0.0808	0.0808	6.6	0.012	No	High as methylmercury	0.0889	0.909	No	0.00917	No
Molybdenum	2.04	2.04	5	0.408	No	Low					No
Nickel	31.0	31.0	50	0.619	No	Low to moderate	34.0	0.909	No	0.01351	No
Phosphorus	887	887	-	-	-	Low					No
Potassium	1538	1538	-	-	-	Low					No
Selenium	1.09	1.09	1	1.09	Yes	Moderate to high	1.19	0.909	No	0.0268	No
Silver	0.678	0.678	20	0.0339	No	Low					No
Sodium	50.0	59.1	-	-	-	Low					No
Strontium	51.2	51.2	-	-	-	Low					No
Thallium	0.188	0.188	1	0.188	No	Moderate	0.207	0.909	No	0.00343	No
Tin	1	-	5	-	-	Low					No
Titanium	78.2	78.2	-	-	-	Low					No
Uranium	1.29	1.29	23	0.0563	No	Low					No
Vanadium	43.7	43.7	130	0.336	No	Low					No
Zinc	83.2	83.3	200	0.416	No	High					No

Notes:

CCME = Canadian Council of Ministers of the Environment

[1] *CCME (2013). Soil Quality Guidelines for the Protection of Environmental and Human Health - Agricultural. http://st-ts.ccme.ca/*

[2] *Soil baseline concentrations are from samples collected in 2010, 2011, and 2012.*

(-) = no value

All soil concentrations are dry weight.

The most conservative guideline (either CCME or BC CSR) was used for soil screening purposes.

Gray shading indicates predicted concentrations are below CCME guidelines, or if no guideline is available, or the contaminant does not have bioaccumulative properties; therefore, a second screening step is not required and the contaminant is not retained as a COPC.

Table 18.8-4. Selection of Contaminants of Potential Concern based on Predicted Water Quality in the Country Foods Local Study Area

COPC	Project Phase	Location and Timing of Exceedance
Selenium	Decommissioning and Reclamation	M19A Creek during January, February, and March
	Post-Closure	M19A Creek, during January, February, and March

Source: Chapter 8 and Appendix 8-G

18.8.3.2 Summary of Contaminants of Potential Concern Selected for Country Foods

During the Operation phase, which represents the worst-case scenario for potential changes in the quality of terrestrial country foods, no COPCs were identified based on predicted soil or water quality for inclusion in the country foods effects assessment. The soil ingestion component of the food chain model is the driving force in uptake of COPCs in wildlife. In contrast, changes in COPC concentrations in surface water results in little to minor uptake and accumulation of COPCs in wildlife. No effects to soil quality (or vegetation via root uptake of contaminants) would be expected during any phase of the project since no significant changes in soil quality were identified during the Operation phase. Therefore, no effects to the quality of terrestrial country foods are predicted, and no effects to human health would be predicted.

18.8.3.3 Screening Level Risk Assessment for Selenium in Fish Tissue

Selenium was identified as a Project-related COPC for country foods based on predicted incremental changes in water quality due to Project activities during the Decommissioning and Reclamation, and Post-Closure phases of the Project. Therefore, a screening level risk assessment was done to assess the potential for human health effects due to selenium in country foods during these phases.

Selenium was identified as a COPC in water in M19A Creek during January, February, and March since predicted concentrations are greater than both guideline limits (2 μg/L) and baseline concentrations. Selenium is a bioaccumulative metalloid, which is typically taken up by aquatic organisms through the food web. BC recently released updated selenium guidelines that include a human consumption screening value based on selenium fish tissue residues (Beatty and Russo 2014); this was used as the primary screening criteria for determining whether predicted fish tissue selenium concentrations may pose a risk to human health.

As part of the selenium management plan (Chapter 24.10), a fish bioaccumulation model was developed based on water and fish (Slimy Sculpin) tissue selenium concentrations that were measured during baseline studies for the Project. Although Slimy Sculpin are not typically consumed as food fish, baseline studies for the Project and studies at other mine sites suggest that Slimy Sculpin may accumulate selenium to a greater extent than other potential food fish such as Bull Trout, Brook Trout, Mountain Whitefish, Northern Pike, and Westslope Cutthroat Trout (Table 18.5-8; Teck Coal Ltd. 2012). Therefore, Slimy Sculpin selenium tissue residues may be higher than that of food fish and using these predictions may represent a more conservative estimate of risk to human consumers due to selenium tissue residues in fish consumed as country foods.

The regression relationship for the Slimy Sculpin bioaccumulation model is:

$$Se_{WB} = 2.5262 \times Se_{Wat} + 3.8957$$

where:

Se_{WB} = Fish whole body selenium concentration (µg/g dw)

Se_{Wat} = Water selenium concentration (µg/L)

Mean water quality model predictions for selenium in M19A Creek were used as the water selenium concentration in the bioaccumulation model, which provided predicted fish tissue residues based on predicted water concentrations. Predicted fish tissue residues are shown in Table 18.8-5.

Table 18.8-5. Predicted Selenium Tissue Concentrations for Slimy Sculpin during Decommissioning and Reclamation/Post-Closure Phase at M19A Creek

Month	Mean Predicted Selenium Tissue Concentration (µg/g dw)
January	9.37
February	11.2
March	9.89

Notes:
dw = dry weight
Shaded cells indicate the baseline fish tissue selenium concentration exceeds the BC MOE high fish intake screening value (7.3 µg/g dw; Beatty and Russo 2014).

M19A Creek is the only location where predicted water selenium concentrations exceeded both the guideline and background water concentrations in January, February, and March, only during the Decommissioning and Reclamation, and Post-Closure phases. Although fish were not captured in M19A Creek, the creek was classified as a default 'S4' fish-bearing stream due to a series of beaver dams restricting fish access. For the purposes of this effects assessment, it was assumed that fish will be able to access M19A Creek when the series of beaver dams fail, and develop a resident population. The water selenium guideline is no longer exceeded once water reaches M19 Creek, and therefore, effects to fish in M19 Creek are not predicted.

The predicted selenium tissue residues exceed the high fish intake human consumption screening value of 7.3 µg/g dw (based on consumption of 220 grams of fish per day, every day; Beatty and Russo 2014) in January, February, and March. However, predicted fish tissue selenium concentrations are all below the moderate fish intake (based on consumption of 110 grams of fish per day, every day) screening value of 14.5 µg/g dw. The study completed by Chan et al. (2011) found that the 95^{th} percentile consumption rate for fish (trout and Whitefish combined) by FN individuals was 12.3 grams per day, every day; it is unlikely that a person could consume enough fish from M19A Creek (if sport or food fish were to colonize the creek) for effects to health to occur.

Thus, the predicted fish tissue selenium concentrations likely do not pose a risk to human health since M19A Creek does not contain fish, and if sport or food fish were to colonize the creek, they would have to be consumed at a high intake rate >0.22 kg/day for there to be a risk to human health.

18.8.4 Residual Effects on Human Health from Noise

An Environmental Noise Modelling Study was conducted for the Project by BKL Consultants (Appendix 18-C). The study provides details of the modelling undertaken to assess the environmental effects of noise associated with the proposed Project during the Construction and Operation phases at the Project.

Predicted noise levels during the Construction and Operation phases with respect to human receptors are presented in Tables 18.8-6 to 18.8-9. In line with current best practice, the noise assessment included evaluation of nighttime noise (L_n) for workers at adjacent infrastructure and activities since they may be working night shifts. In addition to sleep disturbance, other potential human health effects due to noise were assessed for non-worker receptor locations.

18.8.4.1 Sleep Disturbance

Tables 18.8-7 and 18.8-8 show predicted noise levels for human receptor locations for non-workers. None of the human receptor locations experience nighttime noise levels greater than the limiting criteria for sleeping outdoors (30 dBA) or indoors (45 dBA) during either Construction or Operation phases.

Table 18.8-6. Noise Predictions at Potential Worker Accommodation Receptor Locations

Receptor	Construction		Operation	
	Average Noise L_d (dBA)	Average Noise L_n (dBA)	Average Noise L_d (dBA)	Average Noise L_n (dBA)
Limiting Criteria	*85*[a]	*85*[a]	*85*[a]	*85*[a]
Facility Near Loadout	36	10	44	30
Trend Mine Washing Plant and Coal Loadout	42	16	52	38
Tumbler Ridge Wind Energy Project	12	2	58	58
Trend Coal Mine	8	0	12	7
Quintette Coal Loadout	46	19	55	32
Quality Wind Project	7	0	14	5
Quintette Coal Mine - Windy Pit	18	7	27	18
Hermann Mine Project	13	5	19	17
Babcock Creek Wind Project	16	2	27	20

Notes:
L_d = daytime sound level
L_n = nighttime sound level
dBA = A-weighted decibel
[a] *WorkSafe BC (2013) based on Occupational Health and Safety Regulation.*

To support the delivery of equipment, material, and supplies it is estimated that up to 20 and 30 vehicles will each make a return trip per day at the peak of the Operation and Construction phases, respectively. Approximately six and three shuttle trips per day will be required to transport personnel to and from the mine site and Tumbler Ridge during Operation and Construction phases, respectively. For this reason, the assessment of noise impact from heavy trucks is based on the predicted maximum noise level (L_{max}) of a heavy truck passing by the closest receivers along the material transport route. Calculated noise levels for heavy trucks do not exceed the limiting criteria of 60 dBA at any human health receptor location (Table 18.8-9).

Table 18.8-7. Noise Predictions during Construction Phase at Human Receptor Locations

Receptor	Baseline			Construction							
	Assumed L_{dn} (dBA)	Adjusted L_{dn} for Rural Quiet Area (dBA)	% HA	Average Noise L_d (dBA)*	Average Noise L_n (dBA)*	Project L_{dn} (dBA)	+5 dB Tonal/Impulsive Penalty (dBA)	Total Adjusted L_{dn} (dBA)	Adjusted L_{dn} for Rural Quiet Area (dBA)	% HA	Δ % HA
Limiting Criteria	-	-	-	*55* [a]	*30 outdoors 45 indoors* [a, b]	-	-	-	*75* [c]	-	*6.5* [c, d]
Tumbler Ridge Health Centre	47	57	5.3	24	0	22	27	37	57	5.3	0
Lions Campground	47	57	5.3	19	0	17	22	32	57	5.3	0
Core Lodge	47	57	5.3	8	0	8	13	23	57	5.3	0
Trapline Cabin 4	47	57	5.3	23	7	22	27	37	57	5.3	0
Trapline Cabin 5	39	49	1.9	49	39	49	54	64	64	12.4	10.5
Trapline Cabin 6	35	45	1.1	10	2	11	16	26	45	1.1	0
Trapline Cabin 7	35	45	1.1	5	0	7	12	22	45	1.1	0
Trapline Cabin 9	47	57	5.3	8	0	7	12	22	57	5.3	0
Hunting Cabin 21	39	49	1.9	6	0	6	11	21	49	1.9	0

Notes:

L_{dn} = day-night equivalent sound level

L_d = daytime sound level

L_n = nighttime sound level

dBA = A-weighted decibel

% HA = percentage of persons highly annoyed

Δ % HA = increase in percentage of persons highly annoyed

** Average noise L_d and L_n are Project noise only and do not include background noise levels.*

[a] *US EPA (1974)*

[b] *WHO (1999)*

[c] *Health Canada (2010f). Useful Information for Environmental Assessments.*

[d] *Michaud, Bly, and Keith (2008)*

Table 18.8-8. Noise Predictions during Operation Phase at Human Receptor Locations

Receptor	Baseline			Operation							
	Assumed L_{dn} (dBA)	Adjusted L_{dn} for Rural Quiet Area (dBA)	% HA	Average Noise L_d (dBA)*	Average Noise L_n (dBA)*	Project L_{dn} (dBA)	+5 dB Tonal/Impulsive Penalty (dBA)	Total Adjusted L_{dn} (dBA)	Adjusted L_{dn} for Rural Quiet Area (dBA)	% HA	Δ % HA
Limiting Criteria	-	-	-	*55* [a]	*30 outdoors 45 indoors* [a, b]	-	-	-	*75* [c]	-	*6.5* [c, d]
Tumbler Ridge Health Centre	47	57	5.3	33	14	31	36	46	57	5.3	0
Lions Campground	47	57	5.3	45	13	43	48	58	61	8.7	3.4
Core Lodge	47	57	5.3	11	7	14	19	29	57	5.3	0
Trapline Cabin 4	47	57	5.3	43	22	41	46	56	60	7.7	2.4
Trapline Cabin 5	39	49	1.9	43	34	43	48	58	59	6.8	4.9
Trapline Cabin 6	35	45	1.1	13	9	16	21	31	45	1.1	0
Trapline Cabin 7	35	45	1.1	5	2	9	14	24	45	1.1	0
Trapline Cabin 9	47	57	5.3	15	8	16	21	31	57	5.3	0
Hunting Cabin 21	39	49	1.9	50	7	48	53	63	63	11.1	9.2

Notes:

L_{dn} = day-night equivalent sound level

L_d = daytime sound level

L_n = nighttime sound level

dBA = A-weighted decibel

% HA = percentage of persons highly annoyed

Δ % HA = increase in percentage of persons highly annoyed

** Average noise L_d and L_n are Project noise only and do not include background noise levels.*

[a] *US EPA (1974)*

[b] *WHO (1999)*

[c] *Health Canada (2010f). Useful Information for Environmental Assessments.*

[d] *Michaud, Bly, and Keith (2008)*

Table 18.8-9. Heavy Truck Passby Maximum Sound Level

Receptor	L_{max} (dBA)
Limiting Criteria	***60***[a]
Quintette Coal Mine	58
Trend Mine Washing Plant and Coal Loadout	46
Facility Near Loadout	41
Trapline Cabin 5	40
Tumbler Ridge Health Centre	28
Lions Campground	24

Notes:
L_{max} = maximum A-weighted, fast time constant sound level
dBA = A-weighted decibel
[a] WHO (1999)

18.8.4.2 Interference with Speech Communication

Predicted daytime (L_d) and nighttime noise levels (L_n) for workers from adjacent projects were below the maximum long-term exposure limit (L_{ex}) of 85 dBA (Table 18.8-6). Therefore, no effects to human health would be expected at these workplace human receptor locations. As seen in Tables 18.8-7 and 18.8-8, all predicted daytime noise levels (L_d) at non-worker receptor locations are below the noise limiting criteria of 55 dB. Therefore, Project-related noise is not predicted to lead to speech interference at the identified human receptor locations.

18.8.4.3 High Annoyance

As mentioned previously, only non-workers are assessed for increased annoyance due to noise. During the Construction phase, noise level predictions show that the change in % HA is marginally greater than 6.5% at Trapline Cabin 5 (by 4%; Table 18.8-7). During Operation, the change in % HA is greater than 6.5% at Hunting Cabin 21 (by 2.7%; Table 18.8-8). However, the % HA metric is a measure of a community's reaction to noise and is not intended to assess a single individual's response towards a project's noise levels (Michaud, Bly, and Keith 2008). Applying the % HA metric to a single receptor at a rustic backcountry cabin rather than a community does not reflect the intent of the guideline, thus the modelled exceedance of the % HA guidance level at these two receptors may overestimate the potential for Project effects. HD Mining will implement a noise management plan (Section 24.3) to mitigate potential noise effects, and will work with individuals as appropriate to address specific noise concerns that may arise. Through these efforts, it is expected that any noise-related issues that could affect human health can be resolved.

Therefore, since % HA is the only metric predicted to exceed guidance levels at the known human receptor locations and that additional mitigation measures are possible, the potential for effects on human health due to noise is unlikely and no residual effects are predicted.

18.8.5 Summary of Residual Effects on Human Health

Table 18.8-10 provides a summary of the assessment of residual effects on human health.

Table 18.8-10. Summary of Residual Effects on Human Health

Valued Component	Project Phase	Project Component / Physical Activity	Description of Cause-Effect	Description of Mitigation Measure(s)	Description of Residual Effect
Human health (potential effects due to drinking water quality)	All Project phases	Site construction/ preparation activities; water management activities (e.g., seepage collection, discharge to the receiving environment); Decommissioning/ reclamation of Project infrastructure	Changes in water quality due to the Project could affect human health through changes in drinking water quality	Water Management Plan; Spill Management Plan; Erosion and Sedimentation Control Plan	No residual effect is predicted
Human health (due to changes in air quality)	All Project phases	Underground Mine Coal Processing Site Shaft Site Secondary Shafts Site Heavy Machinery, Traffic and Transportation.	Changes in air quality due to the Project could affect human health through inhalation of air contaminants	Emission reduction measures; Fugitive dust reduction measures; Air Quality and Dust Control Plan	No residual effect is predicted
Human health (due to changes in quality of country foods)	All Project phases	Underground Mine Coal Processing Site Shaft Site Secondary Shafts Site Heavy Machinery, Traffic and Transportation; Site construction/ preparation activities; water management activities (e.g., seepage collection, discharge to the receiving environment); Decommissioning/ reclamation of Project infrastructure	Project-related changes in environmental media (i.e., soil, water) quality could affect the quality of country foods, which could affect the health of human consumers of country foods	Fugitive dust reduction measures; Air Quality and Dust Control Plan; Water Management Plan; Spill Management Plan; Erosion and Sedimentation Control Plan	No residual effects are predicted.
Human health effects due to noise	All Project phases	Construction equipment, road activities, mining activities.	Project noise sources are predicted to increase noise levels, which could affect human health.	Noise Management Plan (Section 24.3)	No residual effects predicted

18.9 CHARACTERIZING RESIDUAL EFFECTS, SIGNIFICANCE, LIKELIHOOD AND CONFIDENCE ON HUMAN HEALTH

Given that no residual effects to human health were predicted due to Project-related effects on drinking water, air quality, country foods quality, or noise, no significance assessment is required (Chapter 5, Effects Assessment Methodology).

18.10 SUMMARY OF RESIDUAL EFFECTS ASSESSMENT AND SIGNIFICANCE FOR HUMAN HEALTH

After considering mitigation measures, no residual effects on human health due to drinking water quality, air quality, country foods quality, or noise were identified though a predictive, quantitative screening level risk assessment, as described in Sections 18.8.1, 18.8.2, 18.8.3, and 18.8.4 of this assessment.

18.11 CUMULATIVE EFFECTS ASSESSMENT

Given that no Project residual effects to human health were identified, no cumulative effects assessment is required (as described by the effects assessment methodology in Chapter 5).

18.12 EFFECTS ASSESSMENT CONCLUSIONS FOR HUMAN HEALTH

The potential for Project-related effects to human health was assessed by determining the potential for changes in air quality, drinking water quality, country foods quality, or noise and considering how these potential changes could affect human health. Quantitative information was used wherever possible in the assessment, including the outputs from the air quality, water quality, soil quality, and noise predictive models.

The potential for effects to human health was described in Section 18.7.1 (drinking water quality), 18.7.3 (air quality), 18.7.5 (country foods quality), and 18.7.7 (noise). These sections described the key ways in which human health could be affected by these biophysical parameters. Mitigation measures to minimize or avoid the potential for Project-related effects were described in sections 18.7.2 (drinking water quality), 18.7.4 (air quality), 18.7.6 (country foods quality), and 18.7.8 (noise). Predictive models included consideration of the mitigation measures proposed as part of the Project, such that data outputs reflect the best estimate of potential Project effects on air quality, water quality, soil quality, and noise.

After considering mitigation measures, no residual effects on human health due to drinking water quality, air quality, country foods quality, or noise were identified though predictive, quantitative assessments, as described in Sections 18.8.1 (drinking water), 18.8.2 (air quality), 18.8.3 (country foods quality, including consideration of both aquatic and terrestrial effects), and 18.8.4 (noise) of this assessment. Based on the quantitative modelling conducted to support the environmental assessment, effects on human health due to potential Project related changes on water quality, air quality, country foods quality, or noise are not predicted. Given that no Project-related residual effects were identified, no significance determination was conducted and no residual effects on human health were carried forward to cumulative effects assessment.

REFERENCES

Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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

1996. *Mines Act*, RSBC. C. c. 293.

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.

2012. *Canadian Environmental Assessment Act*, SC. C. c. 19. s. s. 52.

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

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.

Achten, C., C. Shubo, K. L. Straub, and T. Hofmann. 2011. The lack of microbial degradation of polycyclic aromatic hydrocarbons from coal-rich soils. *Environmental Pollution*, 159: 623-29.

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

ANSI. 2005. *Quantities and Procedures for Description and Measurement of Environmental Sound - Part 4: Noise Assessment and Prediction of Long-term Community Response*. Reference No. ANSI S12.9-Part 4-2005. American National Standards Institute, Standards Secretariat Acoustical Society of America: Washington, DC.

ASTM. 2010. *Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter), Standard D1739-98*. American Society for Testing and Materials International: West Conshohocken, PA.

BC EAO. 2013. *Guideline for the Selection of Valued Components and Assessment of Potential Effects*. British Columbia Environmental Assessment Office: Victoria, BC.

BC EAO. 2014. *Murray River Coal Project: Application Information Requirements*. With respect to an Application for an Environmental Assessment Certificate pursuant to the Environmental Assessment Act [S.B.C. 2002] c.43. Submitted to: British Columbia Environmental Assessment Office: Victoria, BC.

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. 1999. *Dawson Creek Land and Resource Management Plan*. British Columbia Ministry of Forests Lands and Natural Resources Operations: 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. 2006a. *British Columbia Approved Water Quality Guidelines. 2006 Edition*. British Columbia Ministry of Environment, Environmental Protection Division: Victoria, BC.

BC MOE. 2006b. *A Compendium of Working Water Quality Guidelines for British Columbia*. British Columbia Ministry of Environment, Science and Information Branch. http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html#table1 (accessed accessed in 2009).

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 15, 2013).

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

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

BC MOE. 2013d. *New Ambient Air Quality Criteria for $PM_{2.5}$: Development Process*. British Columbia Ministry of Environment. http://www.bcairquality.ca/regulatory/pm25-development.html (accessed May 2013).

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

BC MOE. 2013f. *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 22, 2013).

BC MOE. 2013g. *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 Oil and Gas Commission. 2009. *British Columbia Noise Control Best Practices Guideline*. BC Oil and Gas Commission: n.p.

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.

Carmichael, N. B. and P. M. Chapman. 2006. *Baseline Selenium in Sculpins Related to the Northeast Coal Zone*. British Columbia Ministry of Environment. http://www.env.gov.bc.ca/epd/regions/omineca/water/reports/pdf/selenium_sculpins.pdf (accessed May 2013).

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

CCME. 1999b. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health: Introduction*. Canadian Quality Guidelines. Canadian Council of Ministers of the Environment: Winnipeg, MB.

CCME. 2012a. *Canadian Sediment Quality Guidelines for Protection of Aquatic Life: Summary Table*. Presented at Environment Canada. Canadian Council of Ministers of the Environment, Ottawa, ON.

CCME. 2012b. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (Agricultural Land): Summary Table*. Environment Canada. Canadian Council of Ministers of the Environment. http://ceqg-rcqe.ccme.ca (accessed December 2012).

CCME. 2012c. *Canadian Water Quality Guidelines for Protection of Aquatic Life: Summary Table*. Presented at Environment Canada. Canadian Council of Ministers of the Environment, Ottawa, ON.

CEAA. 2013a. *Environmental Impact Statement Guidelines for the Murray River Coal Project*. Canadian Environmental Assessment Agency: Vancouver, BC.

CEAA. 2013b. *Operational Policy Statement: Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012*. 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.

Chapman, P. M., J. Downie, A. Maynard, and L. A. Taylor. 1996. Coal and deodorizer residues in marine sediments - contaminants or pollutants? *Environmental Toxicology and Chemistry*, 15 (5): 638-42.

Cowan, J. P. 1993. *Handbook of Environmental Acoustics*. n.p.: John Wiley & Sons.

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).

Environment Canada. 2013a. *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. 2013b. http://www.ec.gc.ca/rnspa-naps/ (National Air Pollution Surveillance Program (NAPS) accessed July 2013).

Government of BC. 2013. *BC Water Resource Atlas*. http://webmaps.gov.bc.ca (accessed May 2013).

Hauck, M., M. A. J. Huijbregts, A. A. Koelmans, C. T. A. Moermond, M. J. Van Den Heuvel-Greve, K. Veltman, A. J. Hendriks, and A. D. Vethaak. 2007. Including sorption to black carbon in modeling bioaccumulation of polycyclic aromatic hydrocarbons: uncertainty analysis and comparison to field data. *Environmental Science & Technology*, 41: 2738-44.

Health Canada. 1992. *Guidelines for Canadian Recreational Water Quality*. Minister of National Health and Welfare: Ottawa, ON.

Health Canada. 1999. The Basics. In *Canadian handbook on health impact assessment*. Ottawa, ON: Health Canada. http://publications.gc.ca/collections/Collection/H46-2-99-235E-1.pdf (accessed March 2013).

Health Canada. 2000. *Decision-Making Framework for Identifying, Assessing, and Managing Health Risks*. Health Canada. http://www.hc-sc.gc.ca/ahc-asc/pubs/hpfb-dgpsa/risk-risques_tc-tm-eng.php (accessed April 18, 2013).

Health Canada. 2004. *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. 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. 2009. *DRAFT: Supplemental Guidance on Human Health Risk Assessment on Air Quality ($HHRA_{AIR}$)*. Contaminated Sites Division, Health Canada: Ottawa, ON.

Health Canada. 2010a. *Draft Federal Contaminated Site Risk Assessment in Canada, Supplemental Guidance on Human Health Risk Assessment for Country Foods ($HHRA_{FOODS}$)*. 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, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals ($DQRA_{CHEM}$)*. Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

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

Health Canada. 2010f. *How Health Canada Contributes to Environmental Assessment*. Environmental Assessment Division, Safe Environments Directorate: Ottawa, ON.

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

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

Health Canada. 2012b. *Guidelines for Canadian Recreational Water Quality, third edition*. Water, Air and Climate Change Bureau, Healthy Environments and Consumer Safety Branch, Health Canada: Ottawa, ON.

Health Canada. 2013. *Ambient Levels of Nitrogen Dioxide*. http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n+C8BFC3F2-1 (accessed April 2014).

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.

Pennart, H. D., R. Crowther, T. Taylor, M. Morden, and S. Mattison. 2004. *The Use of Ecological Risk Assessment for Regional Management of Aquatic Impacts*. n.p.

PMT SRMP. 2006. *The Peace Moberly Tract Draft Sustainable Resource Management Plan*. Government of British Columbia: Victoria , BC.

Pomeroy, K. 2007. *Application for an Environmental Assessment Certificate for the Hermann Mine Project*. Report prepared for the BC Environmental Assessment Office: Victoria, BC.

PRCI. 2010. *Roman Coal Mine Environmental Assessment Report*. Peace River Coal Inc. http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_project_home_308.html (accessed April 2014).

Rescan. 2013a. *Murray River Coal Project: 2010 to 2012 Aquatic Resources Baseline Report*. Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2013b. *Murray River Coal Project: Ethnographic Overview and Traditional Knowledge and Use Desk-based Research Report*. Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, BC.

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.

Talley, J. W., U. Gosh, S. G. Tucker, J. S. Furey, and R. G. Luthy. 2002. Particle-scale understanding of the bioavailability of PAHs in sediment. *Environmental Science & Technology*, 36: 477-83.

Tang, J., E. J. Petersen, Q. Huang, and W. J. J. Weber. 2007. Development of engineered natural organic sorbents for environmental applications: 3. Reducing PAH mobility and bioavailability in contaminated soil and sediment systems. *Environmental Science & Technology*, (2901-2907):

Teck Coal Ltd. 2012. *Appendix 7.10-A: Derivation of a Site Performance Objective for Lotic Fish. Volume 2: Mines Act Permit Amendment Application. Section 7: Environmental Management Plans*. Teck Coal Limited: n.p.

The Firelight Group. 2014. *Saulteau First Nations Knowledge and Use Study for HD Mining Murray River Coal Project*. Prepared by The Firelight Group Research Cooperative on behalf of Saulteau First Nations: 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. 1999. *Guidelines for Carcinogen Risk Assessment*. Review Draft. NCEA-F-0644, July. United States Environmental Protection Agency: Washington, DC.

US EPA. 2005. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. EPA520-R-05-006. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response: Washington, DC.

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. 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. 2013. *Table of Exposure Limits for Chemical and Biological Substances*. The Workers' Compensation Board: n.p.

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

HD Mining International Ltd. Personal Communication: April 24, 2014.