BC EAO EAC Application – Tenas Project

Section 8.0 Health Effects Assessment
Chapter 1 Human Health Valued Component

May 2022

VERSION 1.0

Submitted to:	BC Environmental Assessment Office
Pursuant to:	*Environmental Assessment Act*, S.B.C. 2002, c.43
Submitted by:	Telkwa Coal Limited Suite 1410 – 409 Granville Street Vancouver, BC V6C 1T2

Tenas Project

Section 8.0 Health Effects Assessment
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Abbreviations and Acronyms

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
AAQO	Ambient Air Quality Objective
AIR	Application Information Requirements
AQMP	Air Quality Management Plan (S13.0-C2)
ARD	acid rock drainage
ASILs	Acceptable Source Impact Levels
BAT	best available technologies
BC	British Columbia
BC EAO	British Columbia Environmental Assessment Office
BC MEMLI	British Columbia Ministry of Energy, Mines and Low Carbon Innovation
BC MOH	British Columbia Ministry of Health
BC OGC	BC Oil and Gas Commission
BVLD	Bulkley Valley and Lakes District
C	Chapter
CAAQS	Canadian Ambient Air Quality Standards
CACs	Criteria Air Contaminants
CHHAD	Chemical Health Hazard Assessment Division
CEA	Cumulative Effects Assessment
CEMP	Construction Environmental Management Plan (S13.0-C4)
CMSTHP	Chemicals and Materials Storage, Transfer, and Handling Plan (S13.0-C3)
CO	carbon monoxide
COPCs	Contaminants of Potential Concern
CPP	Coal Processing Plant
CR	concentration ratio
CUS	Cultural Use Study
dAIR	draft Application Information Requirements
DMP	Discharge Management Plan (S13.0-C5)
EAC	Environmental Assessment Certificate
EA	environmental assessments
ECCC	Environment and Climate Change Canada
EMF	electromagnetic fields
EMP	Explosives Management Plan (S13.0-C6)
EPC	Exposure Point Concentration
ESLs	Effect Screening Levels
FMSCP	Fuel Management and Spill Control Plan (S13.0-C7)

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
FSRs	Forest Service Roads
GHGs	greenhouse gases
GovBC	Government of British Columbia
HHMP	Human Health Monitoring Program
HHRA	Human Health Risk Assessment
HI	hazard index/indices
HQs	hazard quotients
IARC	International Agency for Research on Cancer
ILCR	incremental lifetime cancer risk
LSA	Local Study Area
MERP	Mine Emergency Response Plan (S13.0-C9)
ML	metal leaching
ML/ARDMP	Metal Leaching (ML)/Acid Rock Drainage (ARD) Management Plan (S13.0-C12)
MTCP	Minesite Traffic Control Plan (S13.0-C10)
NH_3	ammonia
NO_2	nitrogen dioxide
NOx	nitrogen oxides
non-PAG	non-potentially acid generating
O_3	ozone
OW	Office of the Wet'suwet'en
PAG	potentially-acid generating
PAHs	polycyclic aromatic hydrocarbons
PAMP	Public Access Management Plan (S13.0-C14)
PM	particulate matter
$PM_{2.5}$	particulate matter with diameter equal to or less than 2.5 micrometres (µm)
PM_{10}	particulate matter with diameter equal to or less than 10 micrometres (µm)
POC/COC	Parameters of Concern/Contaminants of Concern
POPC/COPC	Parameters of Potential Concern/Contaminants of Potential Concern
PPR	Private Property Receptor
Project	Tenas Project
PSL	permissible sound levels
PSP	Permanent Sample Plots
RCP	Reclamation and Closure Plan (S13.0-C15)
ROC	receptors of concern
RDBN	Regional District of Bulkley-Nechako
ROM	run-of-mine

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
RPD	relative percent difference
RSA	Regional Study Area
S	Section
SEPSCP	Surface Erosion Protection and Sediment Control Plan (S13.0-C17)
SO_2	sulfur dioxide
SOx	sulphur oxides
TAC	Tenas Access Corridor
TARP	Trigger Action Response Plan
TCL	Telkwa Coal Limited
TCRC	Telkwa Coalmine Recreation Camp
TK	Traditional Knowledge
TPM	total particulate matter
TRV	Toxicity Reference Values
TSP	total suspended particulates
UCLM	upper confidence limit of the mean
UF	uncertainty factor
US EPA	United States Environmental Protection Agency
USA	United States of America
VC	Valued Component
VMP	Vegetation Management Plan (S13.0-C18)
VOC	volatile organic compounds
WHO	World Health Organization
WMP	Wildlife Management Plan (S13.0-C21)
WMPRE	Waste Management Plan for Refuse and Emissions (S13.0-C20)

Units of Measure

Abbreviation or Acronym	Long form of Abbreviation or Acronym
>	greater than
%	percent
%HA	percent highly annoyed
bw	body weight
cm	centimetre
dB	decibel
dBA	A-weighted decibel

Abbreviation or Acronym	Long form of Abbreviation or Acronym
dBL	linear decibel
g	gram
kg	kilogram
km	kilometre
kV	kilovolt
Ld	daytime noise levels
Ldn	day-night sound level
Ln	nighttime noise levels
m	metre
µg	microgram
µm	micrometre
mg/kg	milligrams per kilogram
V	volt
wwt	wet weight

EXECUTIVE SUMMARY

The purpose of this chapter is to present an assessment of potential Project-related and cumulative effects on the Human Health Valued Component (VC). The assessment of Project-related effects and cumulative effects was conducted according to the methods set out in **Section (S) 3.0 Assessment Methodology** of the **Environmental Assessment Certificate (EAC) Application**.

While it is acknowledged that there are many other determinants of human health, this chapter focusses on the assessment of only physical human health. Other determinants of human health are assessed in the **Land and Resource Use VC** (**S6.0-C4) and Community Well-being VC (S6.0-C5)**. Biophysical environment factors contributing to physical human health directly through biochemical linkages (e.g., quality of air, water, soil, and subsistence foods) and biophysical linkages (noise) are included in this chapter.

Existing conditions related to the Human Health VC were described to provide context for the effects assessment. Existing conditions in the Local Study Area (LSA) include air quality, the quality of drinking water, the quality of soil that people come in contact with, the quality of subsistence foods, and existing sound levels.

The assessment of the Human Health VC was further informed by Traditional Knowledge (TK), land use information provided through consultation and engagement with government agencies, Indigenous groups, and the public, and peer-reviewed scientific studies. Indigenous and non-Indigenous Residents and Recreational Land Users were identified as the groups of people (receptors of concern) with the likelihood to experience the greatest exposure and, therefore, the greatest potential risk.

After consideration of mitigation measures incorporated into Project design and additional non-design mitigation measures (e.g., best management practices and proven and/or accepted mitigations used by similar projects), residual effects of the Project to the Human Health VC were characterised and rated as to their Significance.

The effects assessment for residual Project effects was based on the results of a quantitative human health risk assessment (HHRA) following established risk assessment methodology from Health Canada and the British Columbia Ministry of Health (see **Appendix 8.0-A**). The HHRA considers three (3) scenarios:

1. Base Case (for existing conditions),
2. Project Case (Operation), which considers Construction and Operation phases, and
3. Project Case (Closure), which includes both Decommissioning and Reclamation and Post-closure phases.

While all phases of the Project have the potential to result in effects to the Human Health VC, the Operation, Decommissioning and Reclamation and Post-closure phases were predicted to have the greatest potential for effects. Assessment of residual Project effects was based on measurements or predictions of environmental concentrations of Contaminants of Potential Concern (COPCs) for Base Case, predictive modelling using upper-bound estimates of environmental concentrations of COPCs for Project Case, and derivation of the incremental change between Base Case and Project Case.

The following residual effects were identified and characterised:

- changes in Human Health due to Project-related changes in air quality from criteria air contaminants;

- changes in Human Health due to Project-related changes in metal concentrations in environmental media:
  - non-carcinogenic metals (all exposure pathways);
  - carcinogenic metals (ingestion pathway only);
- changes in Human Health due to Project-related increases in ambient noise levels.

The Project's residual effects on the Human Health VC were predicted to be **Not Significant**. Considering this, the Project effects were not expected to alter the integrity of the Human Health VC within the Local Study Area (LSA) beyond an acceptable level.

All residual effects were carried forward into the cumulative effects assessment (CEA) for reasonably foreseeable future projects in the area that may have overlapping effects on the Human Health VC. Cumulative effects on the Human Health VC identified in the CEA were the same as the Project residual effects. The Significance of the cumulative effects were determined to be **Not Significant**, consistent with the conclusions of the Significance characterisation for Project residual effects.

Monitoring and adaptive management measures were recommended to address uncertainties in the predictions and in the assessment.

1. INTRODUCTION

This chapter presents the identification and assessment of residual effects of the Tenas Project (Project) and the cumulative effects on the Human Health Valued Component (VC). The Human Health VC is included in the Environmental Assessment Certificate (EAC) Application because of its fundamental importance to people who live and work in the region where the Project will be developed. The assessment of biophysical residual effects on Human Health (i.e., due to changes in environmental quality) is based on the results of the Human Health Risk Assessment (HHRA) See **Appendix 8.0-A**) and the assessment of the Noise subcomponent of the **Atmospheric Environment VC** (see **S4.0-C1**). Both are based on scientific approaches to evaluate potential environmental effects on Human Health from the Project.

This assessment is comprised of the following steps:

- **Regulatory Context:** a description of the regulatory and policy framework for evaluating human health effects in environmental assessments;
- **Scope of the Assessment:** a description of the assessment scope including issues scoping, rationale for the selection of the Human Health VC, subcomponents and indicators, and definition spatial and temporal boundaries of the assessment;
- **Existing Conditions:** a description of the baseline studies undertaken for the Project, other relevant information, and descriptions of the Human Health VC within the defined spatial boundaries;
- **Assessment of Project-related Effects:** identification of the potential interactions between the Project and the VC, a description of potential adverse effects on the VC, proposed mitigation measures, an evaluation of potential residual effects that remain following implementation of the proposed mitigation measures, and an assessment of residual effects including characterisation of significance;
- **Cumulative Effects Assessment (CEA):** a characterisation of the cumulative effects on the Human Health VC and their significance considering the adverse residual effects of the Project in combination with the adverse residual effects of past, present, and reasonably foreseeable future projects and activities and, (if/where necessary) the development of additional mitigation measures; and
- **Follow-up Strategy:** a presentation of follow-up and monitoring programs to verify assessment predictions, evaluate mitigation effectiveness, including adaptive management to respond to issues identified during the monitoring.

2. REGULATORY CONTEXT

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 British Columbia (BC) under various legislation and policy requirements (Health Canada 1999, 2010a). Under BC's *Environmental Assessment Act,* SBC 2002, c 43 (Government of British Columbia [GovBC] 2002) (*EAA*), an EAC 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 British Columbia Environmental Assessment Office (BC EAO) typically relies on Health Canada and provincial health agencies to assess the adequacy of the Human Health effects assessment component of the EA. 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 (subsistence) foods quality (Health Canada 2010a, 2016a, 2016b, 2017b, 2018, 2019) and provides a list of guidance documents available for conducting human health risk assessments (Health Canada 2010b, 2010c, 2011, 2016c, 2016d, 2016e, 2017a, 2021). The British Columbia Ministry of Health (BC MOH) has also recently developed guidance for the assessment of Human Health for projects under BC jurisdiction (BC MOH 2021). Northern Health, the public health care provider for the northern half of BC, the area in which the Project is located, published human health assessment guidance following Health Canada and United States Environmental Protection Agency (US EPA) guidance documents (Northern Health 2015a, 2015b).

The assessment of Project effects on the Human Health VC has been prepared to fulfill the requirements of the Application Information Requirements (AIR) as approved by the BC EAO (BC EAO 2022), the guidance document titled Useful Information for Environmental Assessments authored by Health Canada (Health Canada 2010a), and the British Columbia Guidance for Prospective Human Health Risk Assessment (BC MOH 2021).

Standards, guidelines, objectives, and/or criteria for air quality, soil quality, and drinking water quality have been put in place by the provincial and federal governments with the goal to protect human health (**Table 2-1**). For the purpose of the assessment of noise effects on the general public, guidance from Health Canada (Health Canada 2017b), as well as BC and international guidance documents (**Table 2-1**) were followed.

Table 2-1: Acts, Regulations, Standards, Guidelines, and/or Objectives Intended to Protect Human Health

Name	Year	Type	Government	Description
Air Quality Objectives and Standards (Government of British Columbia [GovBC] 2021)	2020	Objectives/ Standards	BC	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.
British Columbia Noise Control Best Practices Guideline (BC Oil and Gas	2018	Guidelines	BC	The British Columbia Noise Control Best Practices Guideline published by the BC Oil and Gas Commission outlines the recommended best practices for noise control of operations associated with

Name	Year	Type	Government	Description
Commission [BC OGC] 2018)				facilities in BC under the jurisdiction of the *Oil and Gas Activities Act*, SBC 2008, c 36 (GovBC 2008) and is used to inform the assessment of continuous noise using permissible sound level (PSL) guidelines.
Canadian Ambient Air Quality Standards (CAAQS): State of the Air Report (Canadian Council of Ministers of the Environment [CCME] 2020a)	2020	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, ground-level ozone, sulfur dioxide and nitrogen dioxide, pollutants of concern to human health and major components of smog.
Drinking Water Protection Act, SBC 2001, c. 9 (GovBC 2001)	2001	Act	BC	The 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 BC Reg 200/2003 (GovBC 2003)	2003	Regulation	BC	Schedule A of the Regulation lists water quality standards for potable water for regulated water systems.
Federal Contaminated Site Risk Assessment in Canada, Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 3.0 (Health Canada 2021).	2021	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
Guidelines for Canadian Drinking Water Quality (Health Canada 2020a)	2020	Guidelines	Federal	The Guidelines for Canadian Drinking Water Quality are established by the Federal-Provincial-Territorial Committee on Drinking Water (CDW) and published and periodically updated 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.
Guidelines for Community Noise (World Health Organization [WHO] 1999).	1999	Guideline	International	The scope of the WHO's effort to derive guidelines for community noise is to consolidate actual scientific knowledge on the health effects of community noise and to provide guidance to environmental health authorities and professionals trying

Name	Year	Type	Government	Description
				to protect people from the harmful effects of noise in non-industrial environments
Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety (United States Environmental Protection Agency [US EPA] 1974).	1974	Guideline	International	This 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
Source Drinking Water Quality Guidelines (British Columbia Ministry of Environment and Climate Change Strategy [BC MECCS] 2020)	2020	Guidelines	BC	The source drinking water quality guidelines include thresholds of metals and nutrients for drinking water supply and are updated periodically, with the last update in 2020.

Notes: *BC=British Columbia*

The following source was reviewed for applicability, but was determined to not contain the most recent/relevant information:

- National Ambient Air Quality Objectives for Particulate Matter (Health Canada 1998) (see GovBC 2021 in **Table 2-1** above.

3. Scope of the Assessment

The effects assessment for the Human Health VC, including the assessment of Project-related effects and cumulative effects, was conducted according to the methods set out in **S3.0 Assessment Methodology** of the **EAC Application**. Any VC-specific assessment methods that differ from this approach are described in the relevant subsections of this document. For example, the assessment boundaries specific to the Human Health VC are provided in **3.2.4** and the characterisation criteria specific to the VC are provided in **5.4.1**.

The assessment is informed by Traditional Knowledge (TK), land use information provided through consultation and engagement with government agencies, affected Indigenous groups, and the public, by results of baseline surveys and the **HHRA** (**Appendix 8.0-A**) following established risk assessment methodology (Health Canada 2019; BC MOH 2021). Assumptions made in the HHRA, the level of conservatism, and any resulting uncertainties that could affect the assessment of effects on the Human Health VC are listed throughout the **HHRA** (**Appendix 8.0-A**).

Occupational health of Project workers, visitors and contractors, while on shift, is not assessed in this chapter as they are protected under the *Mines Act*, RSBC 1996, c 293 (GovBC 1996b) the Health, Safety and Reclamation Code for Mines in British Columbia (British Columbia Ministry of Energy, Mines and Low Carbon Innovation [BC MEMLI] 2021) (Code), and off-duty workers and contractors live outside of the Project's footprint while not at work.

3.1 Issues Scoping

Telkwa Coal Ltd. (TCL) has undertaken an engagement and consultation process to support the scoping of issues for the Project. Please refer to **S11.0 Wet'suwet'en Rights and Interests Assessment** and **S12.0 Public Consultation** for details on the consultation and engagement program. This consultation and engagement process has included technical working groups established with Indigenous groups, government agencies, community meetings, one-on-one and small group meetings, regarding key themes of interest and exploration of candidate VCs to represent the themes.

Potential effects on Human Health due to the Project, particularly via potential effects on air quality, drinking water, noise, and fish, were identified as a theme of interest by the Office of the Wet'suwet'en (OW), the general public, and in comments received on the draft AIR.

3.2 Rationale for Selection of Human Health Valued Component (VC)

The VC selection process followed the methodology set out in **S3.0-C1-2.4.1 Selection of and Valued Components (VCs)** of the **EAC Application**. The Human Health VC is included in the EAC Application because of its fundamental importance to people who live and work in the region where the Project will be developed.

3.2.1 Valued Component (VC)

Selecting VCs for assessment is done to focus the EAC Application on the issues of highest concern. Human health is of vital importance to Indigenous groups and communities, non-Indigenous people living near the proposed Project, and government agencies, and is regularly assessed for comparable projects. The assessment of environmental effects on the Human Health VC provides an indication of long-term potential effects of the Project at the level of the individual and most sensitive person through integration of potential effects on environmental quality of air, water, soil, subsistence foods, and noise.

VCs are also scoped into the EA based on issues raised during consultation on the draft AIR with Indigenous communities, government agencies, the public and stakeholders. Concerns about potential effects on human health specifically via effects on air quality, noise, water quality, and harvested (or subsistence) food sources have been included in **Appendix 2.0-A - Tenas Project Valued Components Working Group Comment Tracker** in **S2.0** of the **EAC Application.**

Canadian federal and provincial governments and health authorities 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 effects 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; Northern Health 2015b).

The physical environment factors contribute to physical human health directly through biochemical linkages (e.g., quality of air, water, soil, and subsistence foods) and biophysical linkages (noise). Only physical health is assessed in this chapter, while other determinants of human health are assessed in the Social Effects Assessment **S6.0-C4-Land and Resource Use VC** and **S6.0-C5-Community Well-Being VC** of the **EAC Application**.

Health Canada's Useful Information for Environmental Assessments document (Health Canada 2010a) was used to scope relevant and appropriate linkages into the Human Health assessment. In their guidance to stakeholders and proponents, Health Canada (Health Canada 2010a) has suggested the following components be included in the assessment of Human Health:

- air quality effects;
- contamination of subsistence foods;
- drinking and recreational water quality;
- radiological effects;
- electric and magnetic field (EMF) effects;
- noise effects (or sound);
- HHRA and management;
- multi-media toxicology (air, water, and soil); and
- Indigenous health.

All of the noted components were considered and were included in the assessment if they were found to be applicable to the Project, i.e., effects on air quality, subsistence foods, drinking water quality, and soil quality were addressed through a multi-media HHRA followed by the EA for Human Health, including biophysical aspects of Indigenous health. Recreational water quality, EMF effects, and radiological effects were scoped out from the assessment as they are not relevant to the Project.

EMF-related health effects are also not relevant to the Project assessment. Electromagnetic fields exposure levels from construction of a 25 kilovolt (kV) powerline and a 600 volt (V) substation adjacent to the Coal Processing Plant (CPP) are unlikely to pose health concerns as they are much lower than levels when electric current or fields may be generated in the body that are capable of interfering with the brain, nerves, and heart (WHO 2007; Health Canada 2020b). Electromagnetic fields have been classified by the International Agency for Research on Cancer (IARC) as possibly carcinogenic to humans; however, this is based on animal studies and no correlation has been established linking exposure to EMF with increased cancer risk in humans (IARC 2002; WHO 2007; Health Canada 2020b).

Given the above, the biophysical components for Human Health that are considered in this EA based on their relevancy to the Project are:

- Environmental media: This includes quality of air, drinking water, soil, and subsistence foods, and is based on a HHRA approach (**Appendix 8.0-A**) in which Indigenous groups are included as receptors of concern (ROCs), and
- Noise: Noise is assessed in detail in the Noise subcomponent of the **Atmospheric Environment VC (S4.0-C1)** but will be referenced in this section and will be assessed for Human Health effects.

Study results from other VCs linked to the Human Health VC will be used to inform the effects assessment as outlined in **Table 3.2-1**.

Table 3.2-1: Summary of Rationale for Selection of the Valued Component (VC) and Its Linkages

VC	Rationale for Inclusion	Source of Information	VC Linkages	
			Supporting	**Dependent on:**
Human Health	▪ The Project has the potential to interact with the health of human receptors due to potential changes in air quality, drinking water quality, soil quality, quality of subsistence foods, and noise levels. ▪ Concerns about air quality, water quality, fish, and noise were raised by the public in comments to the dAIR. ▪ Dust, surface water, fish, terrestrial resources, and noise are noted in the consultation record with Indigenous groups, Bulkley Valley residents, Tenas Mine neighbours, and regulatory agencies (BC MFLNRORD, BC EAO, BC MEMPR).	• Issues scoping • Government agencies	▪ Community Well-being ▪ Land and Resource Use	▪ Atmospheric Environment ▪ Surface Water ▪ Groundwater ▪ Terrain and Soils ▪ Vegetation ▪ Fish and Fish Habitat ▪ Wildlife ▪ Avian Species Land and Resource Use

Notes: *BC EAO=British Columbia Environmental Assessment Office; BC MEMPR=British Columbia Ministry of Energy, Mines and Petroleum Resources; BC MFLNRORD=British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development; dAIR=draft Application Information Requirements; VC=Valued Component*

3.2.2 Subcomponents

No subcomponents were identified for the Human Health VC.

3.2.3 Indicators

Indicators are quantitative or qualitative measures used to describe existing VC conditions and trends, and to evaluate potential Project effects and cumulative effects on the VC. The Indicator considered in the assessment of the Human Health VC and the rationale for selection is provided in **Table 3.2-2**.

The indicator for the Human Health VC is the change in human health resulting from changes to the biophysical determinants of health due to Project activities. The evaluation of this indicator was supported by the results of the HHRA (**Appendix 8.0-A**), which was in turn supported by information, analytical results, and predictive modelling results associated with the effects assessment completed for a number of other VCs, including:

- **Atmospheric Environment VC (S4.0-C1)** including Air Quality and Noise subcomponents;
- **Groundwater VC (S4.0-C4);**
- **Surface Water VC (S4.0-C3);**
- **Fish and Fish Habitat VC (S4.0-C6);**
- **Terrain and Soils VC (S4.0-C2);**
- **Vegetation VC (S4.0-C7);**
- **Wildlife VC (S4.0-C8);**
- **Avian Species VC (S4.0-C9);** and
- **Land and Resource Use VC (S6.0-C4).**

The quantitative results of the **HHRA (Appendix 8.**0**-A)** that support the Human Health VC effects assessment are the changes in concentration ratios (CRs) for criteria air contaminants (CACs), hazard quotients (HQs) and hazard index/indices (HIs) for non-carcinogenic Contaminants of Potential Concern (COPCs), and incremental lifetime cancer risk (ILCR) for carcinogenic COPCs; these metrics are further explained and defined in **4.2** of this chapter and in the **HHRA** (**Appendix 8.0-A**). Incremental changes in CRs, HQs and ILCRs between baseline (or Base Case) and future (predicted Project Case) conditions are based on people's exposure to COPCs in the environment due to Project activities.

However, CRs, HQs, HIs, and ILCRs are modelled and not directly measurable. Thus, the change in concentration of COPCs in environmental media is a first indication that human health has the potential to be affected by the Project. As concentration changes are more easily measurable during monitoring and health-based guidelines/standards exist for some COPCs in some media, exceedance of these benchmarks by COPCs in air, water, and soil were also chosen as measurement endpoints for potential human health effects. Similarly, the effects assessment for noise relies on established noise guidelines.

The indicator and the rationale for selection are shown in **Table 3.2-2**.

Table 3.2-2: Indicator for Human Health Valued Component (VC)

Indicator	Rationale for Selection
Change in Human Health from Biophysical Determinants of Health	▪ The Project has the potential to increase concentrations of CACs (SO_2, NO_2, PM_{10}, $PM_{2.5}$, TSP) above health-based benchmarks (guidelines or standards). ▪ The Project has the potential to increase concentrations of contaminants of potential concern (COPCs*) in environmental media (i.e., air, drinking water, soil, and subsistence foods) above Base Case concentrations, and above guidelines applicable to drinking water and soil. ▪ The Project has the potential to increase calculated concentration ratios (CRs), hazard quotients (HQs), and incremental lifetime cancer risks (ILCRs) above acceptable threshold values as a result of the changes in COPC concentrations in environmental media. ▪ The Project has the potential to increase noise levels at receptor locations above background noise levels and above noise guidelines for the protection of human health.

Notes: *CACs=Criteria Air Components; COPCs=Contaminants of Potential Concern; HQ=Hazard Quotient; ILCR=Incremental Lifetime Cancer Risk;* SO_2*=sulphur dioxide;* NO_2*=nitrogen dioxide;* PM_{10}*=particulate matter with diameter </=10*μ*m;* $PM_{2.5}$*=particulate matter with diameter </=2.5*μ*m; TSP=Total suspended particulates*

** Given the nature of the Project, COPCs are metals in air, water, soils, and tissues, and ions in water.*

The indicator, supported by measurement endpoints from the HHRA, was used to evaluate potential adverse effects, characterise predicted residual adverse effects, and determine effect significance. Potential adverse effects from noise and their characterisation are provided in **S4.0-C1 Atmospheric Environment VC.**

3.2.4 Assessment Boundaries

This subsection defines and provides rationale for the selection of the boundaries of the assessment for the Human Health VC. Assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the areas within which the effects of the Project are expected to occur, 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 the Human Health VC, and encompasses possible direct, indirect, and induced effects of the Project on Human Health through the linked VCs, as well as the trends in processes that may be relevant. Because the Human Health VC relies on VCs with different technical boundaries, it generally relies on the linked VC with the widest technical boundary (see **3.2.4.4**).

3.2.4.1 Spatial Boundaries

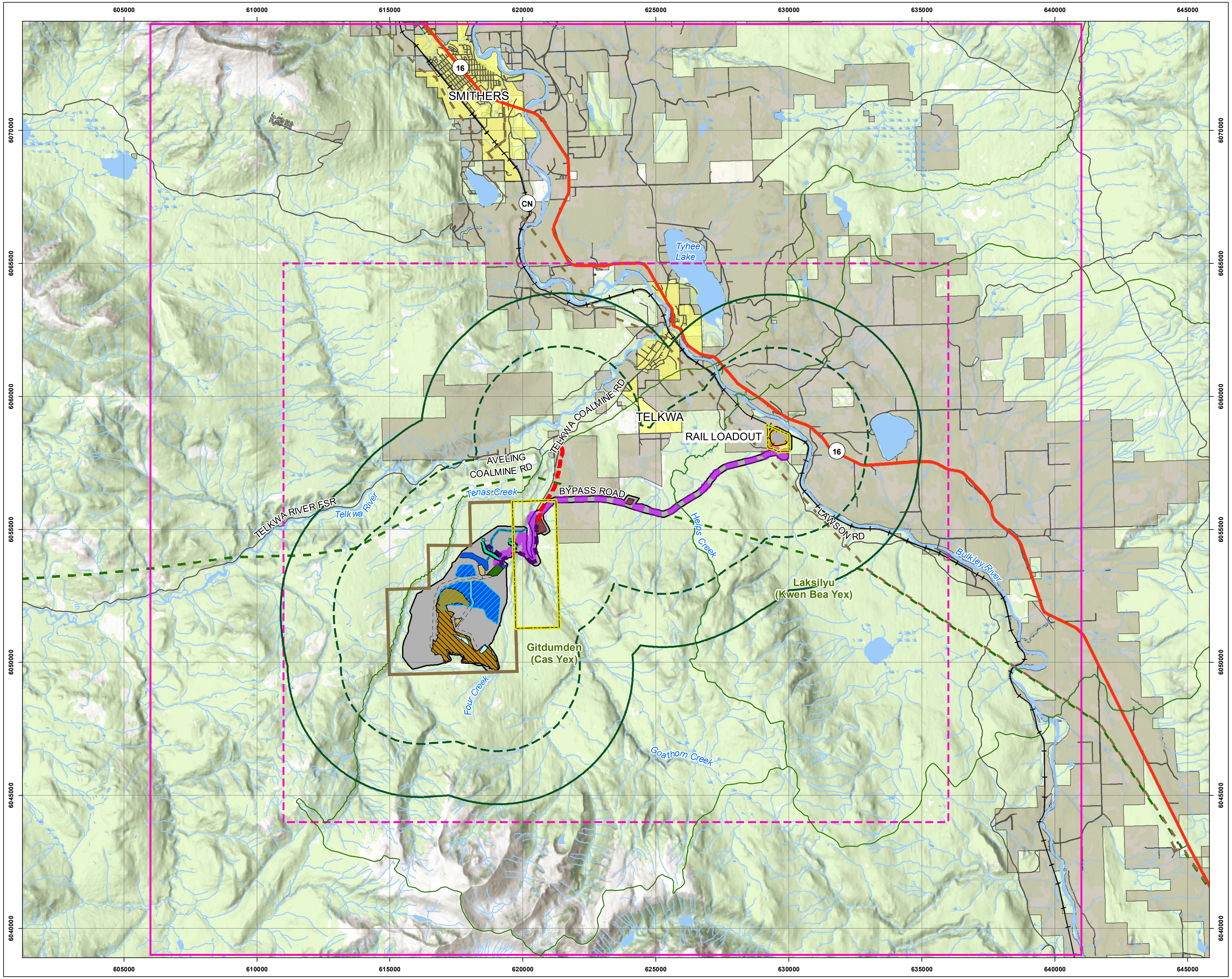
The spatial boundaries for the assessment of the Human Health VC are summarized in **Table 3.2.3** and depicted in **Figure 3.2-1**. A description is provided in the following sections.

Table 3.2-3: Spatial Boundary Definitions for Human Health

Spatial Boundary	Description of Study Area
Environmental Media	
Local Study Area (LSA)	The LSA boundary is the same as the LSA boundary of the HHRA, which is based on the LSA boundary for the Air Quality subcomponent of the Atmospheric Environment VC. The LSA is comprised of a 25 km by 21 km area encompassing a minimum 5 km buffer around the Project, extended north to include the Village of Telkwa.
Regional Study Area (RSA)	The RSA boundary is the same as the RSA boundary for the Air Quality subcomponent of the Atmospheric Environment VC. The RSA is comprised of a 35 km by 35 km square encompassing a minimum 10 km buffer around the Project, extended north to include the populated area of Smithers.
Noise*	
Local Study Area (LSA)	The LSA boundary is the same as the LSA boundary of the Noise subcomponent of the Atmospheric Environment VC and is an area encompassing a 3 km buffer around the Project.
Regional Study Area (RSA)	The RSA boundary is the same as the RSA boundary of the Noise subcomponent of the Atmospheric Environment VC and is an area encompasses a 5 km buffer around the Project.

Notes: *HHRA=Human Health Risk Assessment; km=kilometre; VC=Valued Component*

** Noise study area boundaries are included because noise is a biophysical determinant of human health. However, noise is not considered as a subcomponent of the Human Health VC because potential adverse effects from noise and their characterisation are provided in* ***S4.0-C1 Atmospheric Environment VC.***



Tenas Project

Local Study Areas (LSA) and Regional Study Areas (RSA) for Human Health

Legend

- Rail Line
- Highway
- Road
- Watercourse
- Wetland
- Waterbody
- Municipal Area
- General Private Property
- Wet'suwet'en House Boundary
- 138 kV Transmission Line
- 500 kV Transmission Line

Project Features

- Existing 25 kV Power Line
- 25 kV Power Line
- Haul Road
- Rail Loop
- Discharge Path
- Tenas Access Corridor
- Backfill Area
- Control and Plant Sedimentation Pond
- Explosive Infrastructure
- Management Pond
- Mine Infrastructure Complex
- Open Pit
- Pit Lake
- Quarry
- Rail Infrastructure
- Topsoil Stockpile
- Tenas Coal Licenses
- Telkwa Coal Limited Private Property
- Project Area
- Human Health Regional Study Area
- Human Health Local Study Area
- Noise Regional Study Area
- Noise Local Study Area

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Project line features are for display only.

Sources

- Project Features: Allegiance Coal, April 21, 2021.
- Basedata: Government of British Columbia
- Basemap: World Topo Base

N

1:140,000

0 1 2 3 4 5

Kilometers

NAD 1983 UTM Zone 9N

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TELKWA COAL LIMITED

ERM

3.2.4.1.1 Spatial Boundaries for Human Health due to Changes in Concentration of Criteria Air Contaminants and Contaminants of Potential Concern

The Project Area is the area within which the Project will be constructed and operated, including the Minesite and access routes. The Project footprint is within the Project Area and is where ground will be disturbed, and Project activities will occur.

The LSA for the Human Health VC is the area surrounding and including the Project Area, where there is a reasonable potential for the Project or Project-related activities to interact with and potentially have an effect on the Human Health VC.

The LSA for the Human Health VC is the same as the LSA described for the **HHRA** (**Appendix 8.0-A**) because the HHRA LSA was designed to assess changes due to the Project in all environmental media that influence Human Health (i.e., air, surface water, groundwater, soil, subsistence foods). As described in **Appendix 8.0-A**, the LSA aligns with, or encompasses, the LSAs or modelling domains developed for other VCs and their subcomponents on which the risk assessment depends (e.g., Air Quality, Surface Water Quality). This helps to provide consistency in the EA and allows the results of the risk assessment to be used in the assessment of effects for other VCs. The modelling domain and LSA for the Air Quality subcomponent of the Atmospheric Environment VC was determined to be the largest LSA boundary within which direct effects from Project activities may occur in air, soil and vegetation and, thus, have the potential to affect the Human Health VC. The Surface Water Quality LSA falls within the selected Human Health VC LSA boundary and, thus, no direct effects from the Project on the Surface Water VC and Fish and Fish Habitat VC are expected to occur beyond this area.

The Human Health RSA, which encompasses the LSA, was established to provide a regional context for the assessment of Project effects. The RSA also encompasses the area within which the residual effects of the Project are likely to interact with the residual effects of other past, present, or reasonably foreseeable projects and / or activities to result in a cumulative effect or effects. As a result, the RSA defines the boundaries of the CEA as well. The RSA boundaries for the environmental media are the same as the RSA boundaries for the Air Quality subcomponent of the Atmospheric Environment VC.

3.2.4.1.2 Spatial Boundaries for Human Health due to Noise

Noise study area boundaries are included because noise is a biophysical determinant of human health. However, noise is not considered as a subcomponent of the Human Health VC because potential adverse effects from noise and their characterisation are provided in **S4.0-C1** for the Noise subcomponent of the Atmospheric VC.

The LSA for noise is defined as the area encompassing a 3 kilometre (km) buffer around the Project as illustrated in **Figure 3.2-1**. This 3 km buffer distance is double the criteria boundary for noise of 1.5 km defined by the BC Oil and Gas Commission (BC OGC) (BC OGC 2018) and is expected to capture the area in which there may be Project-related effects on noise. The Noise RSA is defined as the area encompassing a 5 km buffer around the Project to assess potential regional effects.

3.2.4.2 Temporal Boundaries

The temporal boundaries of the Project's Construction, Operation, Decommissioning and Reclamation, and Post-closure phases are described in the EAC Application **(S1.0 Overview of Project Proponent Description**) and shown on **Table 3.2-4**. Human health could potentially be affected throughout the life of the Project.

Table 3.2-4: Temporal Boundaries for the Tenas Project

Phase	Year	Duration (years)	Description of Activities
Construction	-0.5 to 0	1.5	Site clearing, soil salvage, open pit development, building construction, service and haul road development, Rail Infrastructure construction, bridge construction and development of onsite utilities and services. Development of mine rock, and overburden storage piles, stockpiling of reclamation material such as soil, overburden and other materials suitable for reclamation. Development of water management systems and management ponds for storage of potentially acid generating (PAG) materials.
Operation	1 to 21	21	Development of the open pit through drilling, blasting, loading, and hauling functions. Development of mine rock, and overburden storage piles, stockpiling of reclamation material such as soil, overburden and other materials suitable for reclamation. Development of water management systems and management ponds for PAG storage. Conducting coal processing, stockpiling of raw coal prior to processing, and stockpiling of processed coal prior to shipping. Progressive reclamation will be accomplished during operation including, where available, reclamation activities such as sloping, topsoil placement and revegetation.
Decommissioning and Reclamation	22 to 25	4	Tear-down of infrastructure onsite plus reclamation activities, including sloping of storage piles, backfill materials, and placement of reclamation materials including growth media, overburden and non-PAG rock for management pond covers and revegetating surfaces that are planned to be reclaimed.
Post-closure	26 to 50	10	Active: This involves the filling of the open pit with water, monitoring of vegetation growth and water quality for both groundwater and surface water and wildlife. Control and sedimentation ponds may still be needed for settling of total suspended solid levels. The management ponds are left as dry land reclamation except for portions that will be left as open water.
		15	Passive: This stage is when the control and sedimentation ponds are no longer required for settling of total suspended solid (TSS) levels and the management ponds are left as dry land reclamation except for portions that will be left as open water. Telkwa Coal Limited (TCL) is now simply monitoring the site.

3.2.4.3 Administrative Boundaries

No administrative boundaries were identified for the Human Health VC. Indigenous and non-Indigenous hunters, trappers, gatherers, and recreationists were assumed to hunt, fish, collect subsistence foods, or be present throughout the LSA and RSA at any time of the year and were not constrained by administrative boundaries.

3.2.4.4 Technical Boundaries

Technical boundaries refer to technical constraints imposed on the assessment by limitations in the ability to predict the effects of the Project. Human receptor locations influence the assessment boundaries for Human Health because in order for there to be effects on Human Health, humans must be present and be exposed to contaminants or noise. The following sections describe the locations of human receptors for the purpose of the effects assessment, and how the human receptor locations influence the scope or boundaries for the effects assessment.

3.2.4.4.1 Air Quality

Evaluation of land uses within the LSA led to the identification of distinct human receptor locations within the air quality modelling domain (**Appendix 4.1-B Air Quality Model Report** of **S4.0-C1 Atmospheric Environment VC**) that were included in the health assessment (Figure 3.4-1 in **Appendix 8.0-A**). Data sources used to determine human receptor locations included permanent or temporary locations identified in **Appendix 6.4-A Land and Resource Use Baseline Report** of **S6.0-C4 Land and Resource Use VC**, **Appendix 7.1-B Cultural Use Study (CUS)** of **S7.0-C1 Heritage Resources VC** of the **EAC Application**, and during consultation and engagement. Receptor locations for human presence (e.g., residences, cabins, day care centres), and an additional 97 soil and vegetation baseline sampling locations were included in the air quality model.

The **CUS (Appendix 7.1-B)** indicates that there are human health receptor locations within the cultural use study area; however, the report did not identify specific places that could be incorporated into the air quality model as distinct Indigenous receptor sites. Thus, it was assumed that Indigenous and non-Indigenous peoples could be present throughout the LSA and throughout the year, including adjacent to the Project Area.

The air quality human receptor locations (Figure 3.4-1 in **Appendix 8.0-A**) are:

- 76 rural and Telkwa residences;
- Telkwa Elementary School;
- The Ark Playday Centre (Telkwa);
- Tot Spot Family Day Care (Telkwa);
- Telkwa Coalmine Recreation Camp (TCRC); and
- a private cabin.

3.2.4.4.2 Drinking Water

The assessment of potential changes to drinking water quality assumes that land users (Indigenous and non-Indigenous hunters, trappers, gatherers, and recreationists) may drink surface water from streams anywhere inside the LSA during the ice-free period of the year, which may or may not be treated for chemical contaminants (e.g., metals), dependent on the preferred practice of the land user. Therefore, potential receptors for drinking water quality effects are adult land users and toddlers (the most sensitive receptor groups), throughout the LSA and RSA, but constrained to water quality nodes established during baseline studies and predictive modelling (refer to Figure 2-6 in the **Tenas Project - Water and Load Balance Modeling Report** which is **Appendix 4.3-A of S4.0-C3 Surface Water VC** of the **EAC Application)**.

Groundwater wells are also used for drinking water, and within the RSA, the community of Telkwa and rural residences obtain drinking water from wells (refer to Figure 36 of the **Groundwater Technical Report for the Tenas Coal Project, Appendix 1.0-U of the Application)**.

3.2.4.4.3 Soil

The assessment of potential changes to soil quality (i.e., soil COPC concentrations) assumes that land users (Indigenous and non-Indigenous hunters, trappers, gatherers, and recreationists) can be in contact with soil throughout the LSA during snow-free periods of the year. Potential receptors for soil quality effects are adult land users and toddlers (the most sensitive receptor groups) throughout the LSA and RSA, but constrained to soil and vegetation modelling locations established during baseline studies (**Appendix 4.2-A Terrain and Soil Baseline Report** in **S4.0-C2)** and predictive modelling (**Air Quality Modelling Report [Appendix 4.1-B in S4.0-C1], and Appendix 8.0-A**).

3.2.4.4.4 Subsistence Foods

The subsistence foods assessment assumes that land users (Indigenous and non-Indigenous hunters, trappers, gatherers, and recreationists) consume subsistence foods harvested from throughout the LSA, thus, there are no specific receptor locations. To provide a conservative estimate of human exposure to COPCs from subsistence foods, it is assumed that 100 percent (%) of the subsistence foods a person consumes annually were collected or hunted from within the LSA. Potential receptors for subsistence foods quality are adult land users and toddlers (the most sensitive receptor groups) throughout the LSA and RSA, but are constrained to soil and vegetation modelling locations and water quality modelling nodes at fish tissue sampling locations established during baseline studies (Appendix D (Food Chain Model) **of Appendix 8.0-A**).

3.2.4.4.5 Noise

Human receptor locations for noise are categorized into three (3) groups: residing non-worker human receptors, Project employees, and workers from adjacent infrastructure and activity sites. However, since Project workers are governed by the *Mines Act*, RSBC 1996, c 293 (GovBC 1996b), and the Code while on shift, and other workers are protected under regulations by WorkSafe BC (Worksafe BC 2014), and will not be sleeping in camps onsite but will be returning to Telkwa and other communities to sleep, only residents were assessed for potential effects from noise.

The Noise RSA falls within the traditional territory of the Wet'suwet'en. Project access roads have been used by Wet'suwet'en and by non-Indigenous recreationists for hunting, fishing, berry picking, and other activities. Rural residences and recreation sites (i.e., the TCRC) have been identified within the Noise RSA.

Receptor locations were defined at private residences, cabins, schools, childcare facilities, and the TCRC located within Project Area, adjacent to the Tenas Access Corridor (TAC). In addition to these receptor points, ambient noise levels were predicted over a uniform receptor grid with a spacing of 50 metres (m) within the noise RSA (**Noise Modelling Report [Appendix 4.1-A** of **S4.0-C1 Atmospheric Environment VC** of the **EAC Application]**).

4. EXISTING CONDITIONS

This subsection describes the existing conditions of the Human Health VC based on TK, scientific and other information, and baseline studies completed for the Project. As human health is affected by several physico-chemical environmental components, the quality of drinking water, the quality of air that people breathe, the quality of soil that people come in contact with, the quality of subsistence foods, and sound levels were included to describe existing conditions (termed “Base Case” in **Appendix 8.0-A**).

Ultimately, existing conditions for the Human Health VC are best summarized by the calculated Base Case CRs, HQs, ILCRs, and by comparison of Base Case environmental conditions to the relevant guideline thresholds.

4.1 Background Information and Studies

4.1.1 Traditional Knowledge (TK)

The purpose of this subsection is to demonstrate awareness of TK and describe how it influenced the assessment of the effects of the Project on the Human Health VC.

TK is an integral part of the assessment of potential effects on the Human Health VC. TK is included in the **HHRA (Appendix 8.0-A)**, which forms the basis of the VC assessment, for consideration of human health receptor sites (where Indigenous peoples may hunt, fish, gather subsistence foods, or live) and for the determination of subsistence food use (types of foods, frequency, and amount of use).

TK for the Project was obtained through engagement with the Office of the Wet’suwet’en (OW), as well as the **CUS (Appendix 7.1-B)** which compiled a baseline inventory of cultural heritage resources pertaining to Wet’suwet’en communities by examining pre-existing cultural, social, historic, and economic data. The CUS identified a number of subsistence foods that were considered in the HHRA. However, no specific use sites were identified within the LSA, except for one (1) cabin identified by a member of the OW during a 2018 Working Group meeting.

In addition, peer-reviewed literature (see **4.1.2**) was reviewed to obtain qualitative and quantitative information on subsistence food use by Wet’suwet’en peoples. Lastly, quantitative data in the First Nations Food, Nutrition & Environment Study (Chan et al. 2011) and the Davidson Project Country Foods Baseline Assessment (Rescan 2008) were used to inform the HHRA and Human Health VC assessment.

4.1.2 Scientific and Other Information

The purpose of this subsection is to demonstrate awareness of existing scientific and other information, and its applicability to the assessment. As stated in **4.1.1**, peer-reviewed scientific literature (Gottesfeld 1994a, 1994b, 1999; Main Johnson 2013) was reviewed to identify additional information on current use of traditional resources in the LSA.

Other information sources that were consulted were the submissions prepared by the OW in regard to other projects proposed in their territory (OW 2013, 2014). Also, a memorandum prepared for the Pacific Trails Pipeline Limited Partnership (Ardea Biological Consulting 2014) identified a number of animal and plant species and potential tissues that were considered for the HHRA.

Toxicological literature and databases were consulted to identify health effects, toxicity benchmarks, bioconcentration, and bioaccumulation factors, as described in **Appendix 8.0-A**.

4.1.3 Baseline Studies

Table 4.1-1 provides an overview of the type of baseline studies relevant to Human Health and conducted for the Project and the years that these studies spanned.

Table 4.1-1: Summary of Desktop and Field Studies Relevant to Human Health

Study Name	Study Purpose, Duration and Spatial Boundaries
Human Health Risk Assessment (Appendix 8.0-A)	Base Case human health was assessed as part of the HHRA and included information from baseline studies and years listed in this table.
Tenas Project 2017 to 2019 Baseline Report – Ch. 3 Air Quality (Appendix 4.1-C)	The study assessed provincial monitoring data for CACs and measured baseline dust and particulate matter and metals in dust within the LSA boundaries. Data were included for the period from 2014 to 2020. In the HHRA: • CAC data were used to calculate Base Case concentration ratios (CRs) using ambient air quality objective (AAQO) and standards. • Metals in dust data were used to calculate Base Case health risk from inhalation of COPCs.
Tenas Project 2017 to 2019 Baseline Report - Ch. 8 Surface Water Quality (Appendix 4.1-C)	The study assessed baseline surface water quality in creeks, streams, and rivers in the LSA and included data collected between 2006 and 2019 and historical data from the British Columbia Environmental Monitoring System. In the HHRA, data were used to: • select COPCs in drinking water; • calculate Base Case health risk from ingestion of surface water; • calculate, in conjunction with fish tissue data, water-to-fish bioconcentration factors; and • calculate Base Case quality of subsistence foods using the food chain model.
Terrain and Soils Baseline Report (Appendix 4.2-A)	The study included metal analysis data for surface soil samples obtained in 2017 and 2018 from 77 sites within the LSA. Soil samples were gathered from 29 of the sites where vegetation was also sampled. In the HHRA, data were used to: • select COPCs in soil; • calculate Base Case health risk from inadvertent ingestion of soil; • calculate, in conjunction with co-collected vegetation samples, soil-vegetation bioconcentration factors; and • calculate Base Case quality of subsistence foods using the food chain model.
Vegetation and Ecosystems Baseline Report (Appendix 4.7-A)	The study included metal analysis data for 150 samples from 23 plant species obtained between 2017 and 2019 from 74 sites within the LSA. In the HHRA, data were used to: • calculate subsistence foods benchmarks; • calculate Base Case health risk from ingestion of plants; and • calculate Base Case quality of subsistence foods using the food chain model.

Study Name	Study Purpose, Duration and Spatial Boundaries
Tenas Project 2017 to 2019 Baseline Report - Ch. 11 Fish and Fish Habitat (Appendix 4.1-C)	The fish and fish habitat baseline study was conducted in 2017-2018 and included adult rainbow trout tissue sampling at receiving and reference environment sites in the Bulkley River, Telkwa River, Goathorn Creek, and Tenas Creek for assessment of fish tissue metal concentrations. In the HHRA, data were used to: • calculate subsistence foods benchmarks; • calculate Base Case health risk from ingestion of fish; and • calculate Base Case quality of subsistence foods using the food chain model.
Cultural Use Study (Appendix 7.1-B)	This study included a description of the current use of traditional resources by Wet'suwet'en. In the HHRA, the study results were used to: • inform the subsistence food component of the Base Case HHRA (types of foods); and • inform the selection of human receptors of concern.
Land and Resource Use Baseline Report (Appendix 6.4-A)	This study included a description of recreational, residential, and other land use activities in the study area (2019). In the HHRA, the study results were used to: • inform the subsistence food component of the Base Case HHRA (types of foods); and • inform the selection of human receptors of concern.
Tenas Project 2017 to 2019 Baseline Report - Ch. 4 Noise Habitat (Appendix 4.1-C)	The Noise Baseline Study was conducted for three (3) locations within the LSA in 2017 and 2018 and reviewed existing noise information from other projects.

Notes: *AAQO=Ambient Air Quality Objectives; HHRA=Human Health Risk Assessment; CACs=Criteria Air Components; CR=Concentration Ratio*

Study methodologies for the baseline studies listed in **Table 4.1-1** are described in the respective baseline studies and were provided by discipline specialists. Data were considered to be of sufficient quantity and quality to support the Base Case HHRA and associated models.

The Base Case HHRA integrated the baseline data from the studies listed in **Table 4.1-1** into comprehensive and quantitative estimates of CRs, HQs, and ILCRs that describe Base Case risks to human health prior to development of the Project. A detailed methodology to derive these measurement indicators is provided in the HHRA (**Appendix 8.0-A**). A brief description is provided below.

- The CR is the ratio between the CAC concentration (in air) and an Ambient Air Quality Objective (AAQO). The CR is only applied to CACs as it is based on concentration and not dose. A CR of 1 was selected as the acceptability threshold for potential health effects from inhalation of CACs, since inhalation is the only exposure route for CACs;
- The total HQ is the sum of all HQs calculated for individual exposure pathways that are complete or operable (i.e., ingestion of water, ingestion of subsistence foods, ingestion and dermal contact with soil, inhalation of dust) for non-carcinogenic COPCs. The total HQ is the ratio between the dose and the Toxicity Reference Value (TRV; a reference dose) of a COPC. The HI is the sum of HQs for non-carcinogenic COPCs with similar target organs or similar target effects;
- As per guidance by Health Canada (2019), Resident Land Users were assumed to be present within the LSA boundaries full-time; hence, an acceptable risk HQ threshold of 1 was deemed appropriate. Exposures for Recreational Land User do not include exposure to media (air, water, soil) when outside of the LSA (i.e., when not present in the LSA). Therefore, a HQ threshold of 0.2

was deemed appropriate and conservative for the Recreational Receptor for non-carcinogenic COPCs; and

- The ILCR is calculated by multiplying the lifetime average daily dose of a carcinogenic COPC with its slope factor or unit risk. Cancer risks are deemed acceptable by BC MOH (2021) and Health Canada (Health Canada 2013, 2019) where estimated ILCR is less than 1 in 100,000 ($\leq 1 \times 10^{-5}$).

TRVs, slope factors, and unit risk factors were selected following guidance by Health Canada (Health Canada 2021).

Standard risk assessment methodology was used to derive these indicators and consisted of five (5) steps as described in **Appendix 8.0-A**: Problem Formulation, Exposure Assessment, Toxicity Assessment, Risk Characterization, and Uncertainty Analysis.

4.2 Description of Existing Conditions

This subsection describes the existing conditions for the Human Health VC in the LSA, for which the HHRA was completed using quantitative Base Case input data. The subsection provides a description of pre-Project conditions (i.e., conditions prior to interaction with the Project), based on TK, scientific and other information, and relevant baseline studies (listed in **4.1.3**) completed for the Project. The baseline case (Base Case) was assessed by evaluating the potential health risks associated with existing relevant physico-chemical stressors, obtained from the results of regional monitoring and/or the results of a Project-specific baseline environmental sampling program. Base Case results are presented alongside Project Case results in **5.4** to provide ease of comparison.

The purpose of the existing conditions subsection presented in this chapter is not to repeat information provided in other chapters that support the Human Health VC, but rather to present information of relevance to the health effects assessment Base Case discussion that has not been addressed elsewhere in the Application. The following discussion below therefore focuses on the following:

- description of past and present activities in the LSA that have the potential to affect human health;
- description of people (termed “human receptors of concern”) and their use of the land and where this use occurs;
- information related to the use of subsistence foods;
- Base Case sources and types of COPCs and how they can be transported in the environment and taken up by people;
- consideration of concentration of CACs with respect to receptor locations and AAQOs and resulting Base Case CRs; and
- the effect of Base Case COPC concentrations in surface water, groundwater, air, soil, and subsistence foods on the Human Health VC using the Base Case HQ and ILCR for non-carcinogenic and carcinogenic COPCs, respectively.

A complete description of existing baseline conditions for Noise was completed in the Noise Effects Assessment (**S4.0-C1--4.2**). As a result, there is no further discussion of noise baseline characterisation in this chapter.

4.2.1 Past and Present Projects and Activities

The LSA is used extensively for a variety of land uses. Existing (past and present) land uses, and natural resource uses that contribute to Base Case human health include:

- agriculture (range tenures and part-time farming);

- forestry;
- mining;
- oil and gas;
- power transmission lines;
- rail and road (Highway and local roads) transportation;
- traditional and non-traditional land use (i.e., harvesting including fishing, hunting, trapping, and gathering);
- recreation (i.e., hiking, skiing, horseback riding, camping, motorized recreation); and
- drinking water use.

Approximately 1,300 residents live in the Village of Telkwa, based on the 2016 census (Statistics Canada 2016). The Village of Telkwa is on a central water distribution system operated by the Village. Rural properties commonly have domestic groundwater wells as a source of drinking and irrigation water. The Town of Smithers (population 5,351 based on the 2016 census) is located within the Human Health RSA. The communities are connected by Highway 16.

- Recreation and tourism on public lands, including park land (Tyhee Lake Provincial Park), and wildlife and fish harvesting are common activities within the LSA and RSA. Several hiking trails and trail heads are located within the Human Health LSA and RSA, such as the Telkwa Pass Trail road, Cottonwood trail, Aldermere Trail, and Hunter Basin Road and trail, although the loss of Goathorn Creek Bridge has made access to Hunter Basin difficult.

The Telkwa Valley has a history of coal mining, and past and current mine exploration. The powerline crossing the “Bulbous Toe”, a slow-moving landslide west of Telkwa, requires periodic maintenance via the Telkwa Pass Trail road. There is currently a natural gas pipeline approximately seven (7) km northwest of the Project, owned by Pacific Northern Gas Ltd.

The current land use activities contribute to current air quality and noise in the LSA, while past and current land uses have contributed to the quality of soils, surface water, groundwater, and subsistence foods.

4.2.2 Human Receptors of Concern and Receptor Locations

4.2.2.1 Human Health Receptors of Concern

Human Health Receptors of Concern (ROCs) is the technical term applied to people anticipated to be present in the Human Health LSA. They were selected with consideration of activities that are known or reasonably expected to occur in the LSA and additionally, were selected based on likelihood to experience the greatest exposure and, therefore, potential risk.

Project workers, visitors, and contractors are not assessed in this chapter or in the **HHRA** (**Appendix 8.0-A**) as they are governed by the *Mines Act*, RSBC 1996, c 293 (GovBC 1996b), and the Code while on shift, and off-duty workers live offsite while not at work. Thus, exposure of off-duty workers would be similar to that of a visitor to the LSA or that of a resident, assuming conservatively that most workers live within the LSA.

Based on the **CUS** (**Appendix 7.1-B**) and the **Land and Resource Use Baseline (Appendix 6.4-A**), members of the Wet’suwet’en, local residents of the Village of Telkwa, and non-local recreational land users were selected for quantitative evaluation in the HHRA. While it is possible to identify many other land user groups in the LSA, these three (3) groups are likely to have the greatest exposure to Base Case and future Project condition risks due to their proximity to the Project, their use of subsistence foods, and their long-term duration of exposure. Based on their land use characteristics, the three (3) user groups can be identified by two groups of ROCs:

1. **Indigenous and non-Indigenous Resident Land User** (infants to adults): These ROCs live in the Human Health LSA in residential areas (e.g., Telkwa and rural residences) and spend time fishing, hunting, collecting, or farming subsistence foods for their own consumption (in addition to eating store-bought foods). They may drink water from groundwater at their residences and/or surface water while spending time on the land within the LSA;
2. **Recreational Land Users**: These ROCs do not live in the LSA but may spend some time in the LSA to recreate. While doing so, they are assumed to drink surface water from within the LSA and eat store-bought and subsistence foods. This group includes campers, hikers, horseback riders, and other recreationists who do not live in Telkwa or at rural properties within the LSA; and
3. In the Base Case, both groups have exposure to past and present projects and activities in the LSA. See **Appendix 8.0-A** for a detailed account of receptor characteristics and assumptions.

4.2.2.2 Receptor Locations

Receptor locations were chosen based on the known presence of sensitive human user groups (i.e., Telkwa Elementary School, Ark Playday Centre, Tot Spot Family Day Care, TCRC), information from consultation on the draft AIR (Wet'suwet'en cabin), through engagement with the OW, and known residences along the Telkwa Coalmine Road, Lawson Road, the proposed Bypass Road, and Rail Infrastructure. As locations for subsistence food hunting and gathering were not known, vegetation and soil sampling locations were incorporated as conservative receptor locations. Known groundwater wells in close proximity to and downgradient from the Project were used as conservative receptor locations for groundwater users. Surface water receptor locations were based on Base Case surface water and fish sampling locations at the surface water quality modelling nodes. See **Appendix 4.3-A Tenas Project - Water and Load Balance Modeling Report**.

Locations for Base Case air quality and noise measurements overlapped with receptor locations described above, although they were not necessarily the same. This is common for Base Case assessments, which can only assess air quality and noise at a small number of locations, compared to modelling which can incorporate a large number of receptor sites. However, air quality and noise at Base Case locations are assumed to apply throughout the LSA in the Base Case.

4.2.3 Subsistence Foods Selected for Evaluation

4.2.3.1 Indigenous Subsistence Foods

Subsistence foods include a wide range of animal, plant, and mushroom species that are harvested for medicinal or nutritional use.

As indicated in the Project Description (Telkwa Coal Ltd. 2018) and **CUS (Appendix 7.1-B)**, Wet'suwet'en people currently hunt and trap primarily from April to December, although hunting and trapping can take place at any time of the year. Main targeted species include moose, deer, bear, and beaver. Other species harvested for subsistence food, fur, or other purposes include coyote, wolf, lynx, marmots, snowshoe hare, rabbit, muskrats, squirrel, marten, weasel, groundhogs, and blue grouse. For conservation reasons, mountain goat and caribou are generally not hunted.

The LSA is not known to contain hunting areas that are favoured by the Wet'suwet'en. For example, the Telkwa Pass area, an area where Wet'suwet'en are known to prefer to hunt grouse, is outside the Human Health LSA and RSA (TERA 2015, *in* Crossroads 2021). However, there are several indigenous use trails that cross the LSA, with one (1) trail being located adjacent (west) of the Minesite (meeting with members of OW, 18 Sept 2018, refer to Part C Appendix 11). Some of these trails are used currently for recreation.

Chinook salmon are traditionally the first salmon species to be harvested during the year, followed by sockeye in late June and early July. While salmon may be an important harvested fish species, to be conservative in an HHRA it is important to select a non-anadromous fish that obtain all or most of its food from aquatic habitats within the LSA throughout its lifecycle. This is because fish that spend some or all of their lifecycle outside of the Project LSA (e.g., salmon that spend the majority of their adult life stage in the marine environment) will not be affected by Project-related changes in the aquatic environment in the Human Health LSA or will be less affected than a non-anadromous, resident fish species.

Other important fish species include kokanee, whitefish, trout, char, suckers, and freshwater lingcod. Burbot, chub, dace, Dolly Varden, northern pikeminnow, sculpin, and white sturgeon are harvested as well (**CUS [Appendix 7.1-B]**).

Plants are harvested for food, materials, and medicines from forests and woodlands. Plant foods include green vegetables, fruits and berries, inner bark-cambium, roots and rhizomes, and ingredients to make beverages. Huckleberries, soapberries, cranberries, raspberries, saskatoon berries, high-bush blueberries, gooseberries, salmonberries, juniper berries, and thimbleberries are harvested during late summer and autumn at a large scale. The names and uses of 59 species of vascular plants and three (3) nonvascular taxa were documented in studies by Gottesfeld (1994a, 1994b, 1999).

Today, however, substantially fewer Wet'suwet'en persons gather plants for food, medicine, and cultural goods due to concerns over contamination from industrial herbicides used by forestry. Potential threats to the continuity of Wet'suwet'en way-of-life from climate change, industrial development, and resource extraction are of great concern to many Wet'suwet'en today companies **(Appendix 7.1-B CUS)**.

4.2.3.2 Non-Indigenous Subsistence Foods

Non-indigenous people also consume subsistence foods in the form of hunted and gathered foods and subsistence foods obtained from range lands and part-time farming. A local outfitter, Skeena Mountain Guide Outfitters, offers hunts for black bear, mountain goat, wolf, and moose. In Wildlife Management Unit 6-9, which overlaps with the Human Health LSA, resident hunters have harvested moose most successfully, followed by black bears and mule deer (data from 2007 to 2017, **Appendix 6.4-A Land and Resource Use Baseline Report** of **S6.0-C4 Land and Resource Use VC**). Most hunting takes place south of the Minesite but residents hunt in most green spaces throughout the Bulkley Valley.

Fishing is an important food source and recreational opportunity in the Bulkley Valley. Licences are available in a range of options from single day to annual licences. The Bulkley River is a well-known fishing location and the fishing lodges in the region primarily fish on the Bulkley River for steelhead trout. The Telkwa River can only be fished by residents from September to October and does not allow guiding days. The Telkwa River is a favoured spot for resident anglers. It is recognized for it's wild coho and steelhead runs, as well as it's bull trout fishery. The Telkwa River has enhanced spawning habitat for Coho salmon (**Appendix 6.4-A Land and Resource Use Baseline Report** of **S6.0-C4 Land and Resource Use VC**).

The main species of fish caught in the LSA are salmon and steelhead trout, particularly on the Bulkley River and in the Telkwa River.

The LSA includes Goathorn Creek and Tenas Creek, which feeds into the Telkwa River, and the Bulkley River. During the interviews for **Appendix 6.4-A Land and Resource Use Baseline Report** of **S6.0-C4 Land and Resource Use VC**), there were no comments made about the usage of Tenas Creek and Goathorn Creek. Although Tenas Creek and Goathorn Creek are not known as popular fishing locations, there could potentially be fishermen using these creeks and, thus, they were included in the assessment.

Rural land owners may engage in part time farming, to supplement income from other sources such as mining, forestry and the service industry (Regional District of Bulkley-Nechako [RDBN] 2012). The products generated on the farm are normally sold to local consumers based on a desire to eat and support local agriculture, as well as the distance to large grocery stores (RDBN 2012). Although subsistence foods are defined as those that may be produced in an agricultural or backyard setting, they do not include foods grown for commercial sale (Health Canada 2018). Therefore, only foods grown by residents on private farms or gardens for personal use were included in the assessment.

4.2.3.3 Selected Subsistence Foods

Some of the species mentioned above may only be used for materials and not for food, and not all subsistence food species can be evaluated in an HHRA. Therefore, based on the available information, the following representative subsistence food species and groups were assessed:

- moose and mule deer, selected as representatives for commonly consumed herbivorous large mammals;
- American black bear, selected as representative for commonly consumed omnivorous large mammal;
- snowshoe hare, selected as representative for commonly consumed small herbivorous mammal;
- ruffed grouse, selected as representative for commonly consumed birds;
- rainbow trout, selected as representative for commonly consumed non-anadromous fish species with sufficient baseline data;
- berries, selected as commonly gathered and grown food with sufficient baseline data; and
- above-ground vegetation (leaves), selected as commonly grown food with sufficient baseline data.

4.2.4 Types, Sources, and Transport Pathways of Contaminants of Potential Concern (COPC)

4.2.4.1 Base Case Sources and Types of Contaminants of Potential Concern (COPC)

The sources of COPCs in the Base Case are from the water, soil, air, and subsistence foods (fish, berries, and vegetation) in the Human Health LSA. Subsistence foods animals were not sampled during baseline studies and thus, COPC concentrations in animal tissues were modelled. Given the nature of the Project, Base Case COPCs are metals and ions in water, metals in soils and tissues, polycyclic aromatic hydrocarbons (PAHs) and hydrocarbons in water and soil, and CACs and metals in air. Some of the COPCs in the Base Case are naturally occurring (e.g., metals or ions in surface water or metals in dust from re-suspended soil particles in air), while some may be due to past and current anthropogenic sources or activities within the Human Health LSA (e.g., air emissions from vehicles on roads, smoke from wood burning, see **4.2.1**).

Contaminants of potential concern can have different characteristics and can be described as CACs, non-threshold COPCs and threshold COPCs, and carcinogens and non-carcinogens. The following defines each term:

- **CACs** are a set of air pollutants that can cause smog, acid rain, and other health hazards. They include total particulate matter (TPM), particulate matter (PM) with diameter equal to or less than 2.5 micrometre (μm) and 10 μm ($PM_{2.5}$ and PM_{10}, respectively), nitrogen oxides (NOx); a group of gases consisting primarily of nitric oxide [NO] and nitrogen dioxide [NO_2], sulphur oxides (SOx); a group of gases consisting mainly of sulphur dioxide [SO_2], ozone (O_3), carbon monoxide (CO), volatile organic compounds (VOCs), and ammonia (NH_3). PM consists of solid or liquid particles of varied chemical constituents;
- **Non-threshold contaminants** are considered to pose a non-zero health risk at any level of exposure with risks expected to increase with increasing exposure. Non-threshold contaminants

are typically carcinogens, however, there are some air contaminants for which thresholds for non-carcinogenic effects (e.g., respiratory and cardiovascular morbidity and mortality) have not been quantified, including $PM_{2.5}$, O_3, and nitrogen dioxide (NO_2), as well as lead (Health Canada 2013, 2016e, 2019);

- **Threshold contaminants** are considered to have a threshold level below which no adverse effects to are anticipated to occur to Human Health. The health effect can be either be non-cancerous or cancerous (e.g., arsenic; (Health Canada 2019). Above the threshold, a linear dose-response relationship is generally assumed;
- **Carcinogens** are contaminants that are genotoxic or mutagenic by binding to or reacting with DNA, thereby inducing "permanent, transmissible changes in the amount, chemical properties or structures of the genetic material. In most cases, mutation involves changes in DNA structure that either have no effect or cause harm" (US EPA 2005, in Health Canada 2013)). Typical harm is the development of cancer; and
- In contrast, **non-carcinogens** are contaminants that cause health risks other than cancer.

4.2.4.2 Exposure Pathways

The term exposure pathway applies to a potential route by which a receptor can come in contact with a COPC in the environment, for example, exposure to substances in air via inhalation of dust. All applicable exposure pathways for the Base Case (and Project Case) were evaluated in the HHRA and details on the methodology and assumptions for assessing risk levels from these exposure pathways are presented in **Appendix 8.0-A**. Complete exposure pathways (i.e., important and operable exposure pathways) for evaluation in the Base and Project Case were:

- For Indigenous and non-Indigenous Resident Land User:
  - inhalation of CACs in air;
  - incidental ingestion of soil;
  - ingestion of drinking water from groundwater and surface water;
  - ingestion of subsistence foods;
  - dermal contact to soil;
  - ingestion of market (store-bought) foods;
- For Recreational Land User:
  - inhalation of CACs in air;
  - incidental ingestion of soil;
  - ingestion of drinking water from surface water;
  - ingestion of subsistence foods;
  - dermal contact to soil; and
  - ingestion of market (store-bought) foods.

4.2.5 Selection of Contaminants of Potential Concern (COPC)

Not all substances require assessment. Only substances with sufficiently high concentrations to have a potential to affect human health are included in the HHRA as a COPC and in the effects assessment for the Human Health VC. PAHs and hydrocarbons were considered during COPC screening, but not carried forward because their concentrations were well below guidelines in rock and coal samples (**Appendix 8.0-A**). A multi-step process was used to identify COPCs:

1. Base Case (and predicted Project) concentration data were compiled for each environmental medium (air, dust, surface water, groundwater, soil, fish tissue, and vegetation tissue) and maximum concentrations within the LSA were identified;
2. Appropriate media- and land use-specific screening levels from provincial and federal sources were identified. A list of sources is provided in Section 3.5 of the **HHRA (Appendix 8.0-A);**
3. The maximum substance concentration in each medium was compared to the appropriate screening level. If the maximum concentration was less than or equal to a screening level, the substance was not carried forward as a COPC. If the concentration was higher than the screening benchmark in one medium, it was assessed as a COPC in all media and for all exposure pathways;
4. Bioaccumulative substances were included as COPCs even if their maximum concentration did not exceed screening levels; and
5. If screening levels were not available, the substance was also considered a COPC.

The following subsections summarize data, data sources, screening levels, and results for the selection of COPCs in environmental media considered for the assessment of this Project. Details are provided in **Appendix 8.0-A.**

4.2.5.1 Air Quality

Dustfall samples at four locations throughout the LSA were analysed for metals in 2017-2018. Raw dustfall metal data are presented in **Appendix 4.1-C Tenas Project 2017 to 2019 Baseline Report** (Ch. 3 Air Quality)**.** Based on dustfall metal concentrations, metals in PM_{10} were calculated for the assessment of metal inhalation at station PM-Private Property Receptor (PPR) 2[1] as the most representative station near the proposed Project location with the highest potential for change (**Appendix 8.0-A**). The metal concentrations attached to PM_{10} were screened against the Ontario Ambient Air Quality Criteria (Ontario MOE 2012), the Texas State Effect Screening Levels (ESLs; Texas CEQ 2016), and Washington State Acceptable Source Impact Levels (ASILs; Washington State 2019) for chronic durations for metal concentrations in air as BC does not have such criteria. Metal concentrations were well below all of the screening criteria.

4.2.5.2 Drinking Water Quality

Water quality is assessed in the EAC Application **S4.0-C3 Surface Water VC** and **S4.0-C4 Groundwater VC**. Full details on baseline sampling methodology, baseline data, and summary statistics of drinking water quality parameters are presented in **Appendix 4.1-C** and **Appendix 1.0-U Groundwater Technical Report for the Tenas Coal Project**).

Base Case drinking water quality was based on existing concentration of metals in groundwater and surface water in relation to Health Canada Drinking Water Guidelines (Health Canada 2020a), BC Source Drinking Water Quality Guidelines (British Columbia Ministry of Environment and Climate Change Strategy [BC MECCS] 2020), and BC CSR Schedule 3.2 – Drinking Water standards.

The HHRA surface water dataset for COPC screening included data collected between 2006 and 2020 from locations within the study area (WQS01 to WQS17, and historical data from the British Columbia Environmental Monitoring System (**Appendix 8.0-A**). Baseline groundwater quality data were compiled for domestic wells downgradient of and nearest to the Project that are or have the potential to be used for

[1] The designation Private Property Receptor (PPR) 2 is used to protect identity and privacy of property owner/resident. For further details on PPR 2, see the **Human Health Risk Assessment (HHRA)** presented as **Appendix 8.0-A**.

drinking water. Domestic groundwater wells were sampled between June 2018 and April 2019 at five (5) rural residential locations.

Metals identified as COPCs based on their maximum concentration exceeding health-based drinking water screening benchmarks under Base Case (or Project Case) conditions were included in the calculation of Base Case HQs and ILCRs. Cobalt was identified as a COPC in surface water, while arsenic, cobalt, iron, and manganese were identified as COPCs in groundwater under Base Case conditions. Details of the screening procedure can be found in **Appendix 8.0-A.**

4.2.5.3 Soil Quality

Soil quality is assessed in the EAC Application **S4.0-C2 Terrain and Soils VC**. Full details on baseline sampling methodology, baseline data, and summary statistics of soil quality parameters are presented in **Appendix 4.2-A Terrain and Soils Baseline Report**.

Baseline soil quality samples were collected in 2017 and 2018. All soil quality samples collected in the study area, except locations under future development at the Minesite and Rail Infrastructure where soils would likely be disturbed/removed during the Operation Phase, were used for the purpose of screening for COPCs in soil and for the calculation of exposure point concentrations. This resulted in the inclusion of 30 soil baseline samples. Locations adjacent to development areas at the Minesite, Bypass Road, and Rail Infrastructure that are unlikely to be disturbed were included in the dataset, although they are not expected to be accessible to land users during Construction, Operation, and Decommissioning and Reclamation phases. This provides for a conservative assessment for potential exposures in the Post-closure Phase when public access is re-opened. This also ensures that Base Case and Project Case datasets are directly comparable.

Metals identified as COPCs based on their maximum concentration exceeding the most stringent of applicable agriculture and parkland or wildlands CCME guidelines and BC CSR Schedule 3.1 standards under Base Case conditions were included in the calculation of Base Case HQs and ILCRs. These metals were aluminum, arsenic, boron, cadmium, and iron. Details of the screening procedure can be found in **Appendix 8-A.**

4.2.5.4 Subsistence Food Quality

Selection of subsistence foods was based on quantitative data in the First Nations Food, Nutrition & Environment Study (Chan et al. 2011), the Davidson Project Country Foods Baseline Assessment (Rescan 2008), the **Cultural Use Study** (**Appendix 7.1-B)**, and peer-reviewed scientific literature (Gottesfeld 1994a, 1994b, 1999; Main Johnson 2013).

The subsistence foods identified for evaluation in the HHRA were moose, mule deer, American black bear, snowshoe hare, grouse, rainbow trout, berries, and above-ground plants.

Base Case fish, berry, and plant tissue metal concentrations were measured during baseline studies in 2017, 2018, and 2019. Fish tissue metals are assessed in the EAC Application **S4.0-C6 Fish and Fish Habitat VC** and details of the baseline sampling program and results can be found in **Appendix 4.1-C Tenas Project 2017-2019 Baseline Report**. Vegetation tissue metals are assessed in the EAC Application **S4.0-C7 Vegetation VC** with details of the baseline sampling program and results included in **Appendix 4.7-A Vegetation Baseline Report**.

Fish metal concentrations were measured in rainbow trout muscle tissues sampled from the Bulkley River, Telkwa River, Goathorn Creek, and Tenas Creek. Fish tissue quality guidelines exist only for selenium and mercury.

BC's tissue quality guideline for selenium is based on fish whole-body concentration and provides 1.8 milligrams per kilogram (mg/kg) wet weight (wwt; or 7.3 mg/kg dry weight), based on consumption of up to 220 grams (g) of fish per day (BC ENV 2014) as the most conservative human consumption screening value. Muscle tissue selenium concentrations collected from rainbow trout in the study area ranged from 0.208 mg/kg to 0.710 mg/kg wwt in 2017 and 0.176 mg/kg to 0.99 mg/kg wwt in 2018. The average across all samples was 0.396 mg/kg wwt in 2017 and 0.503 mg/kg wwt in 2018. No fish tissue samples exceeded the BC tissue quality guideline for selenium.

Tissue mercury concentrations did not exceed Health Canada guidelines (0.5 mg/kg wwt; Health Canada 2007) for any of the samples tested. Mercury concentrations ranged from 0.0097 mg/kg wwt to 0.0681 mg/kg in 2017 and 0.0117 mg/kg wwt to 0.0629 mg/kg wwt in 2018.

There are currently no provincial or federal health-based guidelines for plant tissue metal concentrations. Screening benchmarks were back calculated based on the most conservative oral TRV and receptor-specific subsistence foods consumption rates as described in Appendix C **of Appendix 8.0-A**.

Base Case surface water, soil, plant, and fish tissue COPC 95% upper confidence limit of the mean (UCLM) concentrations were used in a food chain model to calculate predicted COPC concentrations in terrestrial animals selected as representative subsistence food items. Details of the food chain model are presented in the **HHRA** in **Appendix 8.0-A**.

4.2.5.5 Market (Store-bought) Food Quality

COPC may also be present in foods in the market (retail or commercial) food system. As per guidance from the BC MOH (2021) and Health Canada (2018, 2019), dose from ingestion of market foods was included in the HHRA to estimate the overall exposure to COPCs from food ingestion. The doses from market foods are independent of the Project as it is assumed that people will consume the same amount of market foods every year, in addition to subsistence foods. Thus, the same dose of COPCs from market foods is applied to the Base Case and Project Case. The dose of COPCs from market foods is provided in Appendix E to the **HHRA (Appendix 8.0-A)**.

4.2.5.6 Summary

As a result of this screening procedure, substances shown in **Table 4.2-1** were selected as COPCs. While this subsection describes the Base Case COPCs, the same screening procedure for COPCs was used for predicted future concentrations (Project Case). The results of screening for COPCs in the Project Case are also shown in **Table 4.2-1** to facilitate comparison of results and ensure that substances identified as COPCs in either Base Case or Project Case were evaluated in both Base Case and Project Case HHRAs.

Table 4.2-1: Contaminants of Potential Concern (COPC) Selected for Assessment for Human Health in Local Study Area (LSA)

Substance	Rationale or Medium in which Substance is a COPC	COPC in Base Case?	COPC in Project Case?
PM_{10}	Air	No	Yes
$PM_{2.5}$	Air	Yes	Yes
Aluminum	▪ Soil ▪ Subsistence Foods	▪ Yes ▪ Yes	▪ Yes ▪ Yes
Arsenic	▪ Soil ▪ Groundwater	▪ Yes ▪ Yes	▪ Yes ▪ No
Barium	▪ Subsistence Foods	▪ Yes	▪ Yes

Substance	Rationale or Medium in which Substance is a COPC	COPC in Base Case?	COPC in Project Case?
Boron	▪ Soil	▪ Yes	▪ Yes
Cadmium	▪ Soil ▪ Subsistence Foods ▪ Bioaccumulative	▪ Yes ▪ No ▪ Yes	▪ Yes ▪ Yes ▪ Yes
Chromium	▪ Air ▪ Subsistence Foods	▪ No ▪ No	▪ Yes ▪ Yes
Cobalt	▪ Surface Water ▪ Groundwater ▪ Subsistence Foods	▪ Yes ▪ Yes ▪ Yes	▪ Yes ▪ Yes ▪ Yes
Iron	▪ Groundwater ▪ Soil ▪ Subsistence Foods	▪ Yes ▪ Yes ▪ Yes	▪ No ▪ Yes ▪ Yes
Lithium	▪ Surface Water ▪ Groundwater ▪ Subsistence Foods	▪ No ▪ No ▪ No	▪ Yes ▪ Yes ▪ Yes
Manganese	▪ Groundwater ▪ Subsistence Foods	▪ Yes ▪ Yes	▪ No ▪ Yes
Mercury	▪ Subsistence Foods ▪ Bioaccumulative	▪ Yes ▪ Yes	▪ Yes ▪ Yes
Molybdenum	▪ Subsistence Foods	▪ No	▪ Yes
Nickel	▪ Subsistence Foods	▪ Yes	▪ Yes
Selenium	▪ Surface Water ▪ Subsistence Foods ▪ Bioaccumulative	▪ No ▪ Yes ▪ Yes	▪ Yes ▪ Yes ▪ Yes
Strontium	▪ Subsistence Foods	▪ Yes	▪ Yes
Thallium	▪ Subsistence Foods	▪ No	▪ Yes
Zinc	▪ Bioaccumulative	▪ Yes	▪ Yes

Note: *COPC=Contaminants of Potential Concern*

4.2.6 Concentration Ratios for Criteria Air Contaminants (CACs) under Existing Conditions

Base Case human health due to existing air quality in the LSA may be affected by natural air emissions (e.g., wind-blown dust), residential emissions (e.g., wood burning) in Telkwa, forestry activity, vehicle traffic and road dust. There are no major industrial facilities within the LSA.

An air quality baseline program was initiated for the Project in 2017. Base Case air quality and dustfall data are presented in **S4.0-C1** and **Appendix 4.1-C.**

It was assumed that data from the monitoring station(s) were representative of all receptor locations in the Base Case scenario. Criteria air contaminants were sampled with one (1) 24-hour Partisol particulate monitoring station and four (4) dustfall stations (one(1) in the Tenas Deposit area where mining is proposed [DF-TenasDep], two (2) along one (1) of the routes proposed for trucks to haul processed coal from the Project's CPP to the Rail Infrastructure [DF-PPR2 and DF-Telkwa], and one (1) within the Rail Infrastructure area where the material would be transferred to railcars [DF-Rail]). Monitored CACs included NO_2, O_3, PM_{10}, and $PM_{2.5}$.

Characterisation of ambient CACs also relied on BC ENV ambient air quality monitoring stations in Telkwa, Smithers, and Houston, and SO_2 was characterised based on results from previous projects in the region. Ambient air quality data were also available from the BC Air Data Archive Website, the BC Lung Association annual BC State of the Air reports, and the PurpleAir website. All baseline air quality data are presented in the air quality baseline report **(Appendix 4.1-C**) and summarized in the HHRA (**Appendix 8.0-A**).

Based on screening results for the Base Case and Project Case maximum CAC concentrations against AAQOs at relevant receptor sites closest to the future Project (TCRC, closest rural residence, and Telkwa residences), PM_{10} (24-hour) and $PM_{2.5}$ (24-hour and annual) both exceeded AAQOs in Telkwa for Project plus Background conditions. Thus, PM_{10} and $PM_{2.5}$ were selected as CACs of potential concern for the air inhalation pathway and CRs were calculated.

There are no health effects expected from other CACs under Base Case conditions as their concentrations were below AAQOs.

The Base Case CRs for 24-hour PM_{10} and 24-hour and annual $PM_{2.5}$ were calculated to estimate Base Case human health risks at relevant receptor sites and are shown in **Table 4.2-2**. Relevant Base Case $PM_{2.5}$ concentrations were available from the BC-ENV Telkwa Station (most recent data obtained in 2014 and 2015) and relevant Base Case PM_{10} concentrations were obtained from the PM-PPR2 baseline measurement location (data obtained in 2018, 2019, 2020). Of the available yearly data, minimum concentrations were used to calculate Base Case CRs to provide a conservative estimate of changes in health risk due to the Project.

Concentration ratios were based on the current BC AAQOs (**Table 4.2-2**). Because the measurement period for PM-PPR2 that had the lowest concentration was less than one (1) year (January 1 to 16, 2020) the CRs are an approximation for health risks. The CRs for 24-hour and annual $PM_{2.5}$ and 24-hour PM_{10} were below one (1) at PM-PPR2, the closest Base Case measurement station to the Project, indicating that there are no Base Case health risks from inhalation of fine particulate matter under existing conditions. This was also observed for data collected in 2018 and 2019 (not shown). Concentration ratios for 24-hour and annual $PM_{2.5}$ were above one (1) in Telkwa, indicating that the concentrations of $PM_{2.5}$ exceed AAQOs and that there is a potential for risks to human health from inhalation of $PM_{2.5}$ for these averaging periods under existing Base Case conditions.

Table 4.2-2: Risk Characterisation (Concentration Ratios) for Criteria Air Contaminants (CACs) at Key Receptor Locations for Base Case

CAC	Averaging Period	BC ENV-Telkwa Station (2015)	Station PM-PPR2* and TCRC	Rural Residence
PM_{10}	24-hour	n/a	0.11[a]	n/a
$PM_{2.5}$	Annual 98th Percentile of 24-Hour Average	**1.36**	0.17[a]	n/a
	Annual Average	**1.34**	0.27[a]	n/a

***Notes**: BC ENV Telkwa=BC Ministry of Environment and Climate Change Strategy ambient air quality monitoring station in the Village of Telkwa; CAC=Criteria Air Contaminant; n/a=not applicable - no measurement available for Base Case (see **Appendix 4.1-C** in **S4.0-C1**); $PM_{2.5}$=particulate matter (PM) with diameter equal to or less than 2.5 micrometre (μm); PM_{10}=particulate matter (PM) with diameter equal to or less than 10 micrometre (μm); PPR=Private Property Receptor; TCRC=Telkwa Coalmine Recreation Camp*

Bold and highlighted numbers indicate a CR greater than 1.

a. Data recorded from January 1 to 16, 2020.

For more information about PPR2, see **Appendix 8.0-A Human Health Risk Assessment (HHRA).*

4.2.7 Hazard Quotients under Existing Base Case Conditions

A HQ is the ratio between the estimated daily dose and the tolerable daily intake (TRV) of a COPC and provides a measure of exposure risk to a COPC for an exposure pathway. The TRV is defined as the amount of a COPC per unit body weight that can be taken into the body each day (e.g., mg/kg body weight/day) with no known risk of adverse health effects. TRVs were obtained from Health Canada (2011, 2021), US EPA (2021), Oak Ridge National Laboratory (2021), and CCME (2020b). Section 5 of **Appendix 8.0-A** provides the TRV values used in this assessment for both carcinogenic (i.e., arsenic) and non-carcinogenic COPCs. A Total HQ is the sum of all HQs calculated for all operable exposure pathways from environmental media (ingestion of water, ingestion of subsistence foods, ingestion and dermal contact with soil, inhalation of dust) for non-carcinogenic COPCs.

As per guidance by Health Canada (2019), Resident Land Users were assumed to be present within the LSA boundaries full time; hence, an acceptable risk threshold HQ of one (1) was deemed appropriate for non-carcinogenic COPCs assessed in the **HHRA**. Exposures for Recreational Land User do not include exposure to media (air, water, soil) when outside of the LSA (i.e., when not recreating in the LSA). Therefore, an acceptable HQ threshold of 0.2 was deemed appropriate and conservative for the Recreational Receptor for non-carcinogenic COPCs.

Total HQ values greater than the acceptable thresholds do not necessarily indicate that adverse health effects will occur since the TRVs are conservative (i.e., protect human health by including additional uncertainty factors) and many of the assumptions made in the HHRA are conservative. A total HQ of greater than the acceptable threshold does suggest that the potential risk to human health may require a more detailed evaluation.

In an EAC Application, the purpose of conducting a HHRA is to quantitatively identify the incremental change in risk to human health due to the proposed Project, rather than the absolute risk. Therefore, in this context, the most important use of the Base Case HHRA results is to provide the basis for determining the relevance and potential for change in human health due to the Project.

Appendix tables G2 to G5 of the **HHRA (Appendix 8.0-A)** provide the Existing Conditions (Base Case) HQs for individual exposure pathways and COPCs and resulting total HQs for each receptor group. COPC with Total HQs greater than 0.2 for the Recreational Land User were: aluminum (toddler only), arsenic, cadmium, chromium, cobalt (toddler only), iron, lithium, manganese, mercury, molybdenum, nickel, selenium, thallium, and zinc. COPC with total HQs greater than one (1) for the Resident Land User were: arsenic, cadmium (toddlers only), manganese, molybdenum (toddlers only), and nickel.

The largest contribution to the total HQs in the Base Case were from market food exposures and not from exposure to subsistence food or other exposure media in the LSA. The focus of the assessment is the potential for incremental change in human health due to Project effects on COPCs in subsistence foods and other exposure media. Thus, it is of interest which COPCs exceed the HQ thresholds under Base Case in these media only. For the Recreational and Resident Land Users, only nickel in subsistence foods was predicted to have a HQ greater than 0.2 (**Appendix 8.0-A** Tables G-2 and G-4) or greater than 1 (**Appendix 8.0-A** Tables G-3 and G-5), respectively.

It is common to make a number of conservative assumptions during a risk assessment which will overestimate the actual risk to human health. If no unacceptable risks are identified using a conservative approach, then it is unlikely that human health will be affected by the exposure pathways considered and the rates used in the assessment. However, identification of potential risks due to existing or background conditions does not necessarily mean that human health will be adversely affected, since the risk has been overestimated intentionally in a screening level HHRA.

It is likely that the existing risk due to nickel in subsistence foods is greatly overestimated due to the conservative assumptions made throughout the HHRA and food chain models. Upper-bound estimates of existing environment media concentrations (i.e., 95% UCLM) were used in the calculations and risk levels would likely be lower if other statistics of more central tendency were used (e.g., median or means). In addition, not all of the subsistence foods that an individual may eat will come from the LSA, as was assumed in the assessment.

4.2.8 Incremental Lifetime Cancer Risk under Existing Conditions

The ILCR is the increase in lifetime cancer risk above the normal risks associated with background exposures. In the context of an EAC Application, it is the increase in the lifetime cancer risk due to Project activities.

Carcinogenicity of non-threshold COPCs is dependent on the exposure pathway. For instance, COPCs that are carcinogenic via inhalation are arsenic, cadmium, chromium, and nickel, while the COPC that is carcinogenic via the ingestion and dermal exposure pathways is arsenic. Inhalation exposures are evaluated based on concentrations and unit risk factors, while ingestion and dermal exposures are evaluated based on doses and slope factors. Thus, inhalation and ingestion/dermal exposure pathways are assessed separately.

The acceptable incremental risk threshold for the ILCR due to the Project is 1.0×10^{-5} (or 1 in 100,000 cases) as determined by BC MOH (2021) and Health Canada (Health Canada 2013, 2019). The derivation of the ILCR is described in Section 6 of the **HHRA** (**Appendix 8.0-A**) and includes the calculation of Base Case, Project Case, and Project-only ILCRs. Only the Project-only ILCR is relevant for assessing the increase in lifetime cancer risk due to the Project; therefore, details of the Base Case calculations are not provided here.

The cancer incidence rate (number of new cases per 100,000 population) of all cancer types across all age groups is approximately 550 new cases per 100,000 in BC in 2018 (BC Cancer 2021), or 5.5×10^{-3} for all age groups per year. For adults greater than (>) 60 years of age, this number is approximately 2×10^{-2} per year.

4.2.9 Noise

As mentioned at the beginning of **4.2**, it is not the purpose of the existing conditions section presented in this chapter to repeat information provided in other chapters that are inputs to the Human Health VC. A complete description of existing Base Case conditions for Noise from the perspective of Human Health was provide in **4.2.4 Noise** of **S4.0-C1** of the **EAC Application**. As a result, there is no further discussion of noise baseline characterisation in this chapter.

4.2.10 Uncertainty in Base Case Characterisation

The process of assessing Base Case risks to human health using HHRA methodology has inherent uncertainties, which are discussed in detail in Section 7 of the **HHRA** (**Appendix 8.0-A**). Despite the uncertainties, assumptions were made, and a conservative approach was taken in order to overestimate rather than underestimate potential Base Case risks. Overall, the uncertainty in the risk estimates for existing Base Case conditions is considered lower than the Project Case.

5. ASSESSMENT OF PROJECT-RELATED EFFECTS

The assessment of Project-related effects includes

- potential Project-related interactions with the Human Health VC,
- potential Project-related effects on Human Health,
- summary of mitigation measures for other VCs that are effective as mitigation measures for Human Health, as well as mitigation measures specific to Human Health, and
- residual effects and significance determination.

5.1 Potential Project-related Interactions with the Human Health Valued Component (VC)

The intention of this subsection is to focus the assessment on those interactions with potential to adversely affect the Human Health VC. To accomplish this task, the potential for interactions between Human Health and identified Project activities are considered. Each potential interaction is rated using the terms provided in **Table 5.1-1** and described in **Table 5.1-2**. Where there are no interactions between the Project and the Human Health VC, the activity is not considered further in the assessment. All activities for which there are potential interactions with the Human Health VC are carried forward and described in **5.2.**

Table 5.1-1: Potential for an Interaction between the Human Health Valued Component (VC) and the Project

Term	Definition
No Interaction	Project activity will not interact with the Human Health Valued Component (VC), no adverse effect is expected; no further consideration is warranted.
Interaction	Interaction between the Project activity and the Human Health VC may have a substantive influence on the short- or long-term integrity of the VC (i.e., measurable, or detectable using the identified indicator). The potential effect(s) of the interaction is considered further in the effects assessment.

Interactions with Project activities and the Human Health VC were based on interactions between Project activities and other VCs that have a direct linkage to Human Health (see **3.2.3**). Project activities that have an interaction with the following VCs were considered to also have an interaction with the Human Health VC as human health is directly and indirectly linked to these VCs via quantitative exposure pathways, as described in **4.2.4**:

- **Atmospheric Environment VC (S4.0-C3)** (including Air Quality and Noise subcomponents);
- **Terrain and Soils VC (S4.0-C2);**
- **Surface Water VC (S4.0-C3);**
- **Groundwater VC (S4.0-C4);**
- **Fish and Fish Habitat VC (S4.0-C6);** and
- **Vegetation VC (S4.0-C7).**

Table 5.1-2 shows the linkages between the Project and Human Health, which includes both direct and indirect effects. A direct effect (or direct linkage or pathway) is an effect that results from a direct interaction between the Project and the Human Health VC, and includes:

- changes in air quality (i.e., CAC concentrations, metals attached to PM_{10}) and potential health effects due to inhalation of airborne CACs;
- changes in the quality of surface water and groundwater and potential health effects due to consumption of the water as drinking water; or,
- changes in noise levels and potential health effects due to noise on human receptors.

Indirect effects (indirect linkage or pathway) are the result of direct effects of the Project on one (1) VC that could lead to other effects on VCs linked to Human Health, and includes:

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

The assessment of the Human Health VC focuses on the Operation, Decommissioning and Reclamation, and Post-closure phases of the Project, as these are the phases with the greatest potential for emissions of COPCs to air and to water. Effects during the Construction Phase will be minor and short-term compared to potential changes associated with the Operation Phase, where mining activities are likely to emit dust and affect water quality parameters, and compared to the Decommissioning and Reclamation, and Post-closure phases, where water quality parameters may experience some effects long-term.

Table 5.1-2: Interactions between Human Health and Valued Components (VCs) with Linkage to Human Health and the Tenas Project

Project Activities	Human Health Valued Component (VC)
Construction	
Transportation of equipment, materials, and personnel	X
Site clearing (surveying, clearing, grubbing, soil salvaging)	X
Construction of Surface Water Management Infrastructure, including channels and ponds (sedimentation, control, management, storage)	X
Construction of Bypass Road and quarries from the Minesite to the Rail Infrastructure	X
Improvements to existing private road and Forest Service Roads	X
Construction of haul roads and service roads within the Minesite	X
Construction of the permanent Goathorn Bridge Crossing over Goathorn Creek	X
Construction of the Coal Processing Plant	X
Construction of fuel and lubricant storage facilities and distribution network	X
Construction of administration buildings (first aid, maintenance, mine dry, warehouse, laboratory, parking, and vehicle wash facilities)	X
Construction of a 25 kilovolt (kV) powerline and a 600 volt (V) substation adjacent to the Coal Processing Plant	X
Construction of Rail Infrastructure including Rail Loop and Loadout connecting to the existing main Canadian National Railway line	X
Installation of water supply wells, storage, and distribution system	X
Construction of the water discharge infrastructure	X
Construction of storage piles for overburden, rock separated from coal in Coal Processing Plant, and stockpiles for topsoil and vegetation management	X
Construction of material handling systems for Minesite, including run-of-mine coal, processed coal, process rock conveyors, and stockpiles	X
Construction of solid waste management systems including recycling and composting facilities	X
Construction of Explosives Magazine (storage building)	X
Employment and labour	
Operation	
Mining the open pit (soil salvaging, drilling and blasting, excavation of material, dewatering, loading, hauling, unloading)	X

Project Activities	Human Health Valued Component (VC)
Operation of Surface Water Management Infrastructure including channels and ponds (sedimentation, control, management, storage)	X
Maintain and use Bypass Road and quarries from the Minesite to the Rail Infrastructure	X
Maintain improved private and Forest Service Roads	X
Maintain haul roads within the Minesite, including service roads	X
Maintain permanent bridge over Goathorn Creek	X
Operate Coal Preparation Plant	X
Maintain fuel and lubricant storage facilities	X
Maintain administration buildings (first aid, maintenance, mine dry, warehouse, laboratory, and vehicle wash facilities)	X
Maintain 25 kV powerline and a 600 V substation adjacent to the Coal Processing Plant	X
Transportation of equipment, materials, and personnel	X
Maintain and use Rail Infrastructure including Rail Loop and Loadout connecting to the existing main Canadian National Railway line	X
Operate water supply wells, storage, and distribution system	
Operate the water discharge infrastructure	
Maintain storage piles for overburden, rock separated from coal in Coal Processing Plant, and stockpiles for topsoil and vegetation management	X
Operate material handling systems for Minesite, including run-of-mine coal, processed coal, process rock conveyors, and stockpiles	X
Operate solid waste management systems including recycling and composting facilities	X
Maintain Explosives Magazine (storage building)	X
Progressive reclamation	X
Employment and labour	
Decommissioning and Reclamation	
Dismantle and remove mining equipment and facilities (including powerline, Rail Infrastructure)	X
Transportation of equipment, materials, and personnel	
Reclamation and closure activities at Minesite	X
Reclamation and closure of Bypass Road and haul roads, including quarries	X

Project Activities	Human Health Valued Component (VC)
Reclamation and closure of permanent bridge over Goathorn Creek	X
Reclamation and closure of powerlines	X
Reclamation and closure of Rail Infrastructure	X
Implement post-mining systems and monitoring	X
Employment and labour	
Post-closure	
Maintain post-mining systems and ongoing monitoring	X
Transportation of equipment, materials, and personnel	
Employment and labour	

Notes:

Interaction (X): Interaction between the Project activity and the VC may have a substantive influence on the short- or long-term integrity of the VC (i.e., measurable, or detectable using the identified indicator). The potential effect(s) of the interaction is considered further in the effects assessment.

No interaction (Blank): Project activity will not interact with the VC; no adverse effect is expected; no further consideration is warranted.

5.2 Potential Project-related Effects

This subsection considers the potential adverse Project-related effects on Human Health arising from expected interactions, as identified in **Table 5.1-2**, between the Human Health VC or other VCs linked to Human Health and the Project, and in relation to the indicator described in **Table 3.2-2**.

As the Human Health VC can potentially be affected by air quality, drinking water quality, soil quality, and quality of subsistence foods, the following sections will summarise the nature of potential effects to these linked VCs and will identify potential effects on Human Health from activities of the Project in each Project phase. Potential Project-related effects on Human Health are due to changes in the concentration of CACs in air, due to changes in concentration of COPCs in environmental media (air, drinking water, soil, subsistence foods), and due to changes in noise levels.

For the assessment of Human Health from contaminants in air, it is 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” Operation scenario was assessed. Year Five (5) represents a worst-case operation scenario when the most run-of-mine (ROM) coal and overburden and rock are expected to be mined, and active mining will be located towards the north end of the open pit extent, which is closest to any sensitive receptors. If no effects were to be predicted in the worst-case scenario, it is unlikely that effects will occur on Human Health during other phases of the Project.

The potential for effects on Human Health from drinking water was assessed for the Operation, Decommissioning and Reclamation, and Post-closure phases of the Project, based on the results of the surface water quality predictive model (SRK 2021) and groundwater quality predictions. Changes to water quality were not predicted for the Construction Phase as it has the lowest potential to affect drinking water quality and hence Human Health.

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

The noise effects assessment focused on the highest activity year of the Operation Phase as this phase is associated with the greatest effect on noise levels generated, as explained above. Less noise is expected during Construction, Decommissioning and Reclamation, and Post-closure phases than the noise generated during the Operation Phase as there is significantly less activity planned in the other phases and, thus, were not modelled in the Noise and Human Health effects assessment. If no effects are predicted for the highest activity year of Operation Phase, it is unlikely that effects will occur on Human Health during other phases of the Project as the expected effect is lower in these phases versus the Operation Phase selected.

Mitigation measures for each potential effect are described in **5.3**.

5.2.1 Potential Project-related Effects on Human Health due to Changes in Air Quality (Criteria Air Contaminants [CACs])

5.2.1.1 Operation Phase

Human receptors are people that either visit or temporarily reside in the LSA and RSA (such as people using the TCRC and hiking and riding trails, or transient or recreational land users who may fish, hunt, or collect berries and other plants near the Project) and people residing in rural residences and in Telkwa.

The assessment for the Atmospheric Environment VC and its Air Quality subcomponent focused on the Operation Phase as this phase is associated with the greatest potential effects on the Air Quality (**S4.0-C1-5 Assessment of Project-related Effects)** Effects during the Construction, Decommissioning and Reclamation, and Post-closure phases are expected to be lower than effects during the worst case year of the Operation Phase, and are effectively captured through the assessment of the Operation Phase (**S4.0-C1-5**).

As shown in **Table 5.1-2**, the majority of Project activities during the Construction and Operation phases interact with Human Health. Many of these interactions are associated with potential changes to air emissions such as exhaust from generators, equipment and machinery, vehicles, or fugitive dust from use of the TAC and the handling and stockpiling of waste rock, raw and washed product coal, and overburden and topsoil, to human receptors through the inhalation pathway. Any potential risk to Human Health from interactions with the Air Quality subcomponent will be captured through the assessment of the Operation Phase air emissions.

During the Operation Phase, the primary effects on the Atmospheric Environment VC and its Air Quality subcomponent (and, thus, to Human Health) are expected to be associated with activities at the Minesite, Coal Processing Plant (CPP), and Rail Infrastructure, as well as associated equipment, vehicles, and locomotives, and the operation of two gravel quarries for road maintenance. Effects associated with other activities such as infrastructure maintenance are expected to be small compared to the overall effects associated with the Operation Phase.

As shown in **Table 5.1-2**, Project activities during the Decommissioning and Reclamation Phase interact with Human Health; however, only low-risk interactions are expected to occur. There are no interactions expected during the Post-closure Phase. There will be limited emission sources during the Decommissioning and Reclamation Phase, and therefore the air quality effects are expected to be substantially less than those during the year with the highest emissions in the Operation Phase.

The potential Human Health effects resulting from reduced air quality involve the body’s respiratory and cardiovascular systems. Effects may range from subtle biological and physical changes to breathing difficulties, wheezing, coughing, and aggravation of existing respiratory and cardiac conditions. Individual reactions depend on the air pollutant, the degree of exposure, the individual’s health status, and genetics. Although everyone is at risk from the health effects of air contaminants, certain individuals are more susceptible such as children, the elderly, and people with cardio-respiratory health problems (Health Canada 2016a).

Total suspended particles (TSP) larger than 10 µm in diameter are primarily deposited in the respiratory tract above the larynx and do not reach the lungs (WHO 2000). The evaluation of particulate air pollution has shifted focus from total TSP to the finer fractions of suspended particles ($PM_{2.5}$ and PM_{10}), as the smaller fractions are responsible for the observed adverse health effects (WHO 2000; Health Canada 2016a). Health Canada (2016a), the WHO (2000), and the US EPA (2012) no longer consider TSP in the evaluation of health effects from particles in air, and instead focus on $PM_{2.5}$ and PM_{10} as those particles can reach the upper air ways (Health Canada 2016e) and the thoracic area of the lungs (WHO 2000). Thus, even though TSP concentrations were predicted by the air quality model, this Human Health effects assessment only considered predicted concentrations of $PM_{2.5}$ and PM_{10}.

$PM_{2.5}$ and PM_{10} pose a risk to Human Health as they can travel into and lodge themselves deeply in the lungs, depending on size of the particle. $PM_{2.5}$ in particular can cause coughing, breathing difficulties, reduced lung function, an increased use of asthma medication, can irritate the eyes and nose, and can cause lung cancer. $PM_{2.5}$ is recognized as a non-threshold pollutant (Health Canada 2016a) and a potential carcinogen (IARC 2013); however, slope factors or unit risk factors are not available to characterise this risk like with carcinogens.

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. However, neither Health Canada nor the US EPA has provided a quantitative estimate of carcinogenic inhalation risk (i.e., a slope factor) for PM (including diesel PM [Health Canada 2016e]) 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 quantitatively. However, it is acknowledged that there is no threshold for PM below which there is no adverse health effect.

5.2.2 Potential Project-related Effects on Human Health due to Changes in Environmental Media Quality

Potential human health effects from exposure to environmental media with elevated COPC concentrations depend on a number of factors such as:

- the concentration and toxicity of the COPC;
- speciation of the metal;
- bioavailability;
- the developmental stage of the human receptor (i.e., adult, toddler, women of child-bearing age);
- whether the body is able to efficiently eliminate the COPC;
- whether the COPC can bioaccumulate;
- the amount of water, soil, or food that is consumed (a function of both time, quantity, and age-specific receptor characteristics); and
- the period of time that a person spends in the area.

Toxicity from metals can result in a variety of health effects depending on the individual COPC and is generally independent of the ingestion exposure route (i.e., the body responds to the COPC in the same way, regardless of whether the COPC comes from surface water, soil, or food ingestion). Metals can disturb biochemical processes and normal body functions and involve several body organ systems such as neurological, cardiovascular, immunological, hematological, gastrointestinal, and musculoskeletal systems. However, toxicity will only occur if humans ingest enough water, soil, or food with sufficiently high concentrations of COPCs, such that toxicity thresholds are surpassed.

Note that although inadvertent spills or leaks may also affect the quality of environmental media, these are assessed separately in **S9.0 Accidents and Malfunctions** and in **S13.0-C7 Fuel Management and Spill Control Plan (FMSCP)** as these are related to occurrences of low likelihood outside of normal operating conditions.

5.2.2.1 Air Quality – Operation Phase

Similar to CACs (see **5.2.1**), metals associated with dust can be emitted by the Project and have the potential to affect Human Health during Operation. Effects during the Construction, Decommissioning and

Reclamation, and Post-closure phases are expected to be lower than effects during the Operation Phase, and are effectively captured through the assessment of the Operation Phase.

Human receptors, exposure pathways, and Project activities that may lead to potential effects on Human Health from inhalation of metals are the same as described in **5.2.1**.

The potential Human Health effects resulting from inhalation of metals in dust involve the body's respiratory system and may range from mild functional impairment to chronic obstructive lung disease, asthma, emphysema, and other lung conditions, depending on the metal compound, its physicochemical form, the dose, exposure conditions, and susceptibility factors in the human receptor (Nemery 1990). Some metals, such as arsenic, cadmium, chromium, and nickel, are considered carcinogenic via the inhalation route (Health Canada 2021).

Indirect Human Health effects can originate from deposition of dust-associated metals onto soils and onto vegetation, as well as subsequent transfer via the food chain to subsistence foods ingested by people (see **5.2.2.4** and **5.2.2.5**).

5.2.2.2 Surface Water Quality – All Phases

A change in surface water quality has the potential to affect Human Health either directly through ingestion of drinking water or indirectly through the food chain through ingestion of subsistence foods (see **5.2.2.5**).

The primary pathways for potential Project effects on surface water quality include seepage from water storage facilities and direct discharge to surface water streams (see **S4.0-C3 Surface Water VC**). Other, minor pathways include changes in water quality due to erosion and sedimentation or dust deposition.

The pathways through which surface water quality could be affected by the Project are described in **S4.0-C3 Surface Water VC.** Metal loading can occur when water comes into contact with previously buried rock, whether non-potentially acid generating (non-PAG) or potentially-acid generating (PAG), which results in release of naturally occurring metals through metal leaching (ML) or acid rock drainage (ARD). In addition, recently blasted rock from active mining may also contain residuals from explosives materials, resulting in elevated levels of nitrite, nitrate, and ammonia. These blasting residuals can also be released through water in contact with blasted rock.

Project discharge is expected to occur as a result of precipitation and runoff in excess of water demand within storage facilities and will be directed to Goathorn Creek via the Tenas Control Pond. Discharge will occur throughout all phases of the Project during the open water season.

Seepage from the Project may occur, but it will not be immediate. Seepage effects are expected to occur primarily near the end of Operation and into Decommissioning and Reclamation or Post-closure phases. Seepage effects are not expected to be observed during the Construction Phase (**S4.0-C3 Surface Water VC)**.

Although no specific surface waterbodies within the LSA or RSA were identified as drinking water sources during recreational or traditional land uses, it is assumed for the purpose of the assessment that surface water could occasionally be used in the summer (when surface water is not covered by ice) by people (e.g., trappers, hunters, and recreational users) for drinking while within the LSA and RSA; however, an annual average water quality input was used conservatively in the HHRA. The LSA and RSA are within driving distance from Telkwa, Smithers, Houston, and other communities, and many land users are likely to bring drinking water from the community water systems or bottled water for day use.

Health Canada recommends that water collected from surface waterbodies always be treated before drinking (Health Canada 2015), because surface water can contain naturally occurring bacteria, viruses, and protozoa. However, it is possible that people may stay at campsites for several days and may drink untreated surface water. Land users may have limited access to water purification systems and, generally, personal water purification systems are not designed to treat metals or other chemicals.

As water moves downstream, certain contaminants (e.g., metals, hydrocarbons, excess nutrients) may be attenuated by natural processes. Examples of natural ecosystem processes are bacteria that use or break down contaminants, vegetation in riparian areas that take up metals, and sediment that absorb metals acting as contaminant sinks. This can decrease the concentrations of COPCs that may be present in surface water downstream of potential sources of COPCs. The surface water quality model (described in **Appendix 4.3-A Tenas Project - Water and Load Balance Modeling Report**) did not include the attenuation of contaminants by natural ecosystem processes; thus, the model is likely to be conservative in this regard.

5.2.2.3 Groundwater – All Phases

Groundwater may change as a result of contact (surface) water infiltrating into the groundwater system during all phases of the Project. Thus, groundwater effects pathways are from seepage. The pathways through which groundwater quality could be affected by the Project are described in **S4.0-C4 Groundwater VC.** During the Construction Phase, groundwater quality downgradient of the Project at locations of private wells is not expected to change.

During the Operation Phase, contact water (i.e., from open pit wall weathering, ML/ARD, and/or blasting) is expected to infiltrate underneath the waste and water management facilities into the ground and migrate slowly through the groundwater system into the valleys. If groundwater influenced by contact water reaches areas with private wells, users could be affected by changes in COPC concentrations compared to existing Base Case concentrations of COPCs.

At the start of the Decommissioning and Reclamation Phase, the groundwater system is expected to progressively reach steady Post-closure Phase conditions. Contact water that entered the groundwater system during the Operation Phase is expected to continue migrating while new contact water from weathering of open pit walls, End Pit Lakes and management ponds enter and migrate through the groundwater system. If groundwater influenced by contact water reaches areas with private wells, users may be affected by changes in parameter concentrations compared to existing Base Case conditions.

5.2.2.4 Soil – All Phases

Soil quality (i.e., with regards to the Human Health VC, the COPC concentrations in surface soil from deposition of metals in dust) has the potential to be affected by Project activities during the Construction and Operation phases. Decommissioning and Reclamation, and Post-closure phase activities are not anticipated to result in any measurable Project-related effects on soil quality, and effects during these phases are effectively captured through the assessment of the Operation Phase.

The pathways through which soil quality could be affected by the Project are described in **S4.0-C2 Terrain and Soils VC** and in the **HHRA (Appendix 8.0-A).** For the effects assessment of the Human Health VC, only soil quality outside of the Project footprint is considered, as the Project footprint will not be accessible to the public until the Post-closure Phase. and will be covered with topsoil and revegetated during the Decommissioning and Reclamation Phase. See **Public Access Management Plan (S13.0-C14**) **(PAMP).**

Surface soil quality outside of the Project footprint and within the LSA can be affected by dust deposition. Dust containing COPCs has the potential to change Base Case surface soil metal concentrations when deposited on surfaces near the Project footprint from Project activities, such as site clearing and developing, construction of infrastructure, road grading, blasting, and materials processing, transport, and handling. Dust would be primarily generated during Construction and Operation phases of the Project, with minimal or none generated in Decommissioning and Reclamation, and in Post-closure phases, respectively. However, once deposited, metals will likely persist in surface soil into the future unless they are transformed and mobilized by microbial action, leached into deeper soils, or are taken up by plants and stored in their tissues.

Dust deposition is directly affected by prevailing wind conditions. Prevailing wind direction at the Tenas Deposit is predominantly from the west-southwest to southwest, following the orientation of the Telkwa River Valley (**S4.0-C1-5).** Thus, soil quality may be affected by dust deposition predominately east-northeast of the Project.

Potential effects on Human Health from a change in soil COPC concentrations can be either direct (i.e., via incidental ingestion of soil or dermal contact with soil) or indirect (i.e., via the food chain, **5.2.2.5**).

5.2.2.5 Subsistence Foods – All Phases

The quality (i.e., the metal composition) of subsistence foods species (**4.2.3**) is directly dependent on metal concentrations in environmental media that these species depend upon (i.e., surface water, soil, vegetation) and on the transfer of metals through the aquatic and terrestrial food chains. Metals occur naturally in environmental media due to local physical and geological processes, but their concentrations could potentially change due to Project activities as discussed in **5.2.2.2** and **5.2.2.4**. Potential effects from the Project on the quality of subsistence foods may occur due to changes in water quality (e.g., due to Project-related seepage or discharge) or due to changes in soil and vegetation quality (i.e., due to deposition of dust).

While it is possible that wildlife (e.g., moose and other terrestrial organisms) could take up contaminants directly from air inhalation, this pathway is considered to be a negligible source of contaminants compared to uptake through the diet (Sample et al. 1997; Environment Canada 2012; BC MOE 2013). Therefore, exposure of subsistence food species to contaminants via the inhalation route has been excluded from further consideration; the primary exposure pathway for subsistence food species to Project-related contaminants is via the food chain.

Potential Project-related effects on subsistence foods could occur throughout Construction, Operation, Reclamation and Decommissioning, and Post-closure phases, but depend on the timing of potential effects on air (dust) and surface water. While deposition of dust-associated metals on soil and vegetation is expected to be most prevalent in the Construction and Operation phases, seepage and discharge of metals to surface waters may occur predominately during Operation and Reclamation and Decommissioning phases and diminishing in the Post-closure Phase.

5.2.3 Potential Project-related Effects on Human Health due to Noise

Noise is defined as any undesirable sound that may irritate people, disturb rest or sleep, cause loss of hearing, or otherwise affect the quality of life of affected individuals. Noise can result in psychological and physiological effects (e.g., stress), mental health effects, and effects on residential behaviour (WHO 1999).

Project activities during the Construction, Operation, Decommissioning and Reclamation phases of the Project will emit noise from haul trucks, operation of Rail Infrastructure, and open-pit mining activities. Limited noise is expected in the Post-closure Phase of the Project. Noise from mining activity during the Operation Phase is expected to be almost continuous, specifically in the areas adjacent to the open pit and the CPP. Decommissioning and Reclamation Phase, and Post-closure Phase noise levels will likely be lower, intermittent, and related to decommissioning activities, or reclamation and maintenance. Human health effects from noise are assessed based on quantitative modeling of sound levels for the Operation Phase presented in **S4.0-C.1 (Appendix 4.1-A Noise Modelling Report).**

In the context of assessing Human Health effects due to noise, potential associations between noise and health indicators, including sleep disturbance, interference with communication, noise complaints and a high level of annoyance, are particularly relevant (WHO 1999, 2011). Hearing loss is not typically considered in EAs because project-related sound levels do not reach sufficiently high levels at human receptor locations to cause permanent damage to hearing (Health Canada 2017b).

5.2.3.1 Sleep Disturbance – Operation Phase

Sleep disturbance encompasses the following: difficulty falling asleep; awakenings; curtailed sleep duration; alterations of sleep stages or depth; and increased body movements during sleep. The effects of sleep disturbance have been shown to include, but are not limited to: increased fatigue; irritability; and decreased concentration and performance (Health Canada 2017b).

5.2.3.2 Interference with Communication – Operation Phase

For good speech comprehension, speech levels should exceed that of background noise by 15 decibels (dB) (Health Canada 2017b). Normal indoor speaking levels are typically 55 to 58 dBA and, thus, an indoor noise level of 40 dBA should be maintained. To sustain good outdoor speech comprehension (where people typically speak louder), background outdoor noise levels for continuous noise should be kept below 55 dBA.

The interference of noise with communication can have health and social consequences, especially for persons with hearing loss, and may compromise learning in children, affect physical health (e.g., vocal pathology, noise-induced hearing loss), compromise speech privacy, and affect social participation by the elderly, thus affecting their emotional health (Brammer and Laroche 2012).

5.2.3.3 Complaints and High Level of Annoyance – Operation Phase

Annoyance due to noise and noise complaints are two (2) of the most common community reactions to noise and are considered indicators of potential Human Health effects. Annoyance due to noise is a highly individual experience (i.e., noise that some people find loud and annoying may either not be noticed at all or not found annoying by others). As there are these individual susceptibilities to noise, the indicator of “Complaints and High Level of Annoyance” is used as a community-level indicator. Based on the documented relationships between noise levels and the nature of complaints, Health Canada advises to calculate the expected change in the percentage of highly annoyed (%HA) people in an average community (Health Canada 2017b) to be used as one of the indicators of potential human health effects. Michaud et al. (2008) stated that a “no reaction” response corresponded to a normalized outdoor day-night sound level (Ldn) of 55 A-weighted decibels (dBA) for the intruding noise and identified a divergence between “sporadic complaints” and “widespread complaints” when the normalized Ldn of the intruding noise (i.e., Project noise) reached 62 dBA.

5.3 Mitigation Measures

This subsection describes mitigation measures to address potential adverse effects of the Project on the Human Health VC, consistent with the definition provided by (BC EAO 2013). Mitigation measures may include applicable standards, guidelines, and BMPs supported by specific guidance documents.

TCL has incorporated several mitigation measures into the Project’s design and/or operational procedures to reduce the magnitude, duration, and extent of effects due to the Project. These Project mitigation measures are outlined in **S1.0** of the **EAC Application** and include Project design aspects such as site selection, selection of best available technologies (BAT) to-date for Project infrastructure and mining equipment, and a commitment to progressive reclamation. Project design measures for the Human Health VC include all of the mitigation measures that will be implemented for the VCs and subcomponents with direct linkages to Human Health, in particular related to the following EA chapters.

- **Atmospheric Environment VC (S4.0-C1):** Project design measures that limit effects on the Air Quality and Noise subcomponents of the Atmospheric VC are expected to mitigate effects on

Human Health by limiting concentration of CACs and PM10-associated metals in air for inhalation, dust deposition on soils and plants for ingestion, and by reducing noise;

- **Terrain and Soils VC (S4.0-C2):** Project design measures that limit effects to the Soil Quality subcomponent of the Terrain and Soils VC are expected to mitigate effects on Human Health by limiting concentrations of COPCs in soils for incidental ingestion and for uptake by plants;
- **Surface Water VC (S4.0-C3)** and **Groundwater VC (S4.0-C4):** Project design measures that limit seepage to groundwater and seepage and discharges to surface water to mitigate effects on the Groundwater and Surface Water VCs are expected to also reduce potential effects on Human Health by mitigating effects on drinking water (from groundwater and surface water) and on subsistence foods (from surface water);
- Mitigation measures in the following EA chapters have relevance to the Human Health VC because they include measures that limit effects on subcomponents that support subsistence foods.
  - **Fish and Fish Habitat VC (S4.0-C6)**;
  - **Vegetation VC (S4.0-C7)**; and
  - **Wildlife VC (S4.0-C8)**.

Mitigations that are the most directly linked to the Human Health VC are described in **5.3.1 to 5.3.13** below**.** These mitigations are based on proven and accepted mitigation used on other similar approved projects in BC that had comparable potential effects on Human Health. These additional mitigation measures are expected to be feasible and effective in a timely manner following implementation. No uncertainties with the feasibility or effectiveness of these mitigation measures have been identified at this time.

Mitigation measures tailored to Project activities that are applicable to the Human Health VC have been incorporated into various management plans for the Project, such as:

- **Air Quality Management Plan (S13.0-C2) (AQMP)**;
- **Chemicals and Materials Storage, Transfer, and Handling Plan (S13.0-C3) (CMSTHP)**;
- **Construction Environmental Management Plan (S13.0-C4) (CEMP)**;
- **Discharge Management Plan (S13.0-C5) (DMP)**;
- **Explosives Management Plan (S13.0-C6) (EMP)**;
- **Fuel Management and Spill Control Plan (S13.0-C7) (FMSCP)**;
- **Mine Emergency Response Plan (S13.0-C9) (MERP)**;
- **Minesite Traffic Control Plan (S13.0-C10) (MTCP)**;
- **Minesite Water Management Plan (S13.0-C11) (MWMP)**;
- **ML/ARD Management Plan (S13.0-C12) (ML/ARDMP)**;
- **Public Access Management Plan (S13.0-C14) (PAMP)**;
- **Reclamation and Closure Plan (S13.0-C15) (RCP)**;
- **Surface Erosion Protection and Sediment Control Plan (S13.0-C17) (SEPSCP)**;
- **Vegetation Management Plan (S13.0-C18) (VMP)**;
- **Waste Management Plan for Refuse and Emissions (S13.0-C20) (WMPRE)**; and
- **Wildlife Management Plan (S13.0-C21) (WMP)**.

The management plans provide additional direction on sequencing, monitoring and adaptive management and the mitigation measures outlined in each plan are expected to be timely and effective following implementation.

The following subsections describe key mitigation measures proposed for linked VCs that mitigate potential effects resulting from emissions, discharges, and noise on Human Health, either by reducing potential effects on air inhalation, ingestion of drinking water, and incidental ingestion of soil, or by indirectly reducing potential effects on the food chain for ingestion of subsistence foods. These key measures are also summarized in **Table 5.3-1**.

5.3.1 Limit Project Footprint and Project Area

To limit the Project footprint and Project Area the Project has been designed to:

- Cluster Project components, including the open pit, stockpiles for ROM coal, processed coal and processed rock, CPP, management ponds, and ancillary facilities such as the Maintenance Facility and Administration Building;
- Align linear Project features (such as powerlines, roads, water distribution) into a common ROW;
- Place Project features within existing or planned Project component footprints to limit the clearing of vegetation and the salvage of reclamation materials (surface soil, woody debris, and overburden). For example, the Minesite buildings will be built in areas previously cleared by forestry activity;
- Minimize the length of haul roads, access roads, and rail line where possible. Use or improve existing roads where practical;
- Utilize a loop design configuration for the rail that requires half the space and subsequent footprint compared to the standard teardrop shape seen at other operating or proposed coal mines in western Canada;
- Place reclamation material (surface soil and woody debris) stockpiles within development areas such as the open pit and haul roads to avoid disturbance, while overburden is directly placed on Project components for future reclamation activities; Limit the Tenas Access Corridor (TAC) to a single lane width for long distances and utilize existing Forest Service Roads (FSRs) or private roads where appropriate;
- Backfill approximately 50% of non-coal material back into the open pit; and
- Place processed rock from the CPP within the management ponds versus a separate permanent pile to avoid any potential acid rock drainage (ARD) from this material and reduce the Project footprint.

5.3.2 Reclamation Measures

The following reclamation measures have been incorporated into the mine design:

- Use progressive reclamation techniques to limit the amount of disturbance at any given time by sequencing the open pit and stockpiles to the extent feasible, backfilling of open pit, and where possible, directly placing growth reclamation materials, and placing excavated materials on previously disturbed areas;
- Salvage reclamation materials (surface soil, woody debris, and overburden), for later use in accordance with the **RCP**;
- Vegetate all temporary surface soil and overburden stockpiles to minimize the potential for erosion and sediment generation, to prevent subsequent potential effects on water quality, and to prevent losses of surface soils;

- Implement progressive reclamation on embankments, buttresses, backfills, TAC cut and fill slopes, and other Project components where possible to minimize fugitive dust emissions and reduce erosion and sediment generation;
- The reclaimed landscape will be shaped and contoured to achieve variations of slope steepness, slope length, aspect, and form to assist in creating landform diversity suitable for the establishment of varied plant communities and to reduce visual effects;
- PAG material deposited in the management ponds will be flooded to prevent acid mine drainage but will also be covered with an engineered cover consisting of non-PAG rock, overburden, and surface soils to allow for terrestrial revegetation; Majority of open pit features (e.g., highwalls and footwalls) are covered/resurfaced/recontoured with non-PAG rock and overburden; and
- Revegetate with native plant species appropriate for the target ecosystems, which will include species for merchantable timber, subsistence foods, and ceremonial purposes in consultation with the Wet'suwet'en.

5.3.3 Transport Measures

The following mitigation measures refer to transport measures:

- Build, maintain, and use the TAC for hauling processed coal to the Rail Infrastructure for the duration of all Project phases to minimize traffic on existing, residential roads after the Construction Phase to minimize traffic on existing, residential roads;
- Build, maintain, and use the TAC for transport of personnel, goods, and services for the duration of all Project phases after the Construction Phase to minimize traffic on existing, residential roads;
- Repair and/or replace and/or upgrade existing FSRs or private roads that will be used as part of the TAC;
- Repair and replace new and existing culverts as required for all Project related transport corridors including the TAC;
- Design and build a permanent clear span bridge over Goathorn Creek and Helps Creek and its related tributaries to provide vehicular access to the Project that will be controlled by TCL;
- Use buses and/or vans for employees and contractors as much as practical to reduce the risk of traffic incidents, and to reduce noise and fugitive dust emissions generated by the Project. Bussing options to Witset and/or Houston to be provided (if requested and based on sufficient employees in these locations) to facilitate potential employees accessing employment opportunities with the Project;
- Use dust suppression agents on the rail cars to reduce fugitive dust generation;
- Cover super B-train trucks when hauling processed coal from the CPP to Rail Infrastructure to reduce fugitive dust emissions from trucks;
- Use water and chemical agents on the TAC to reduce fugitive dust emissions, where and when appropriate;
- Use water and chemical agents, as required, on processed coal and ROM coal stockpiles to reduce fugitive dust emissions resulting from storage and handling;
- Utilize low train speeds (10 kilometres/hour [km/hr] within the Rail Infrastructure, and up to 20 km/hr while entering and exiting the Rail Infrastructure) to mitigate vibration and noise;
- Post a speed limit of 50 km/hr on the TAC, 70 km/hr on Minesite haul roads, and 30 km/hr on Project service roads. Mine haul trucks within the Minesite portion of the Project footprint will have a maximum operating speed of approximately 35 km/hr, given their size and weight; and

- Investigate implementing a no train whistle requirement at the existing level rail crossing in the Village of Telkwa based on consultation with and approval of the Canadian National Railway (CNR).

5.3.4 Blasting Measures

The following mitigation measures apply to blasting:

- Use best management stemming techniques (e.g., type of material, size consistency, loading method, and thickness) that will minimize effects of noise and fugitive dust from blast patterns as and assist in the complete detonation of drill holes to reduce the introduction of nitrogen species into the surrounding rock per the **EMP**;
- Correctly time blasts to minimize effects of noise, vibration, and fugitive dust from blast patterns;
- Keep blast patterns small to minimize effects of noise, vibration, and fugitive dust from blast patterns and to reduce the time that patterns need to sleep or wait until they are blasted which reduces the introduction of nitrogen species into the surrounding rock;
- Monitor actual blast results and implement improvements as required as per the adaptive management process to reduce effects of noise, vibration, fugitive dust and reduce the introduction of nitrogen species into the surrounding rock;
- Use electronic detonators to minimize effects of noise, vibration, and fugitive dust from blast patterns and manage misfires to reduce the introduction of nitrogen into the surrounding environment; and
- Use noiseless lead lines on the surface to minimize the effects of noise from blasts.

5.3.5 Management of Metal Leaching/Acid Rock Drainage (ML/ARD)

The following mitigation measures apply to preventing potential ARD:

- Identify and segregate PAG material while mining the open pit, and place PAG material in management ponds and submerge PAG material under a minimum of 1.0 metre (m) of water within an average of six (6) months after excavation but no longer than 12 months and under at least two (2) m of water once the management pond has met its PAG material storage requirements (North Management Pond is completed first, followed by the East Management Pond and finally the West Management Pond) to prevent potential ARD and subsequent effects on surface water quality;
- Place approximately a one (1) to two (2) m layer of non-PAG rock on top of the submerged PAG material below the active water level of the respective management pond, followed by approximately one (1) to three (3) m layer of overburden to create a dry landform above water, followed by an approximately 30 centimetre (cm) layer of reclamation materials (surface soil) to reduce evaporative losses from the management ponds and provide a landscape more similar to pre-Project development;
- No PAG material will be used in construction of any external piles, pads, roads, embankments, buttresses, or for backfilling the open pit, to prevent potential ARD and subsequent effects on surface water quality;
- Open pit walls will be covered by non-PAG material to limit oxygen and water ingress into the open pit walls and provide a neutralizing effect on the open pit wall material below;
- Some of the open pit walls will be flooded with water to further reduce the likelihood of ARD from the covered open pit walls;
- Establish a material geochemical testing program for future Project exploration drillholes and Operation phase blast holes as part of the blasting program to verify PAG versus non-PAG

materials. Maintain a PAG geological model while the open pit is being mined to reflect any changes observed;

- Maintain a database of geochemical testing results and material placement to avoid the incorrect placement of PAG material and potential ARD with subsequent effects on surface water quality;
- Establish a material tracking system to document the location and type of material being excavated and hauled to avoid misplacement of material and/or remediate any misplacement that may occur;
- Controlled open pit wall blasting will be conducted on both the highwall and footwall to limit the amount of damage to the open pit wall to minimize the potential for particle size reduction and provide pathways for water and oxygen to enter the open walls prior to them being covered;
- Majority of material near the open pit footwall will not be blasted again to minimize the potential of water and oxygen accessing this material;
- Progressive reclamation will be undertaken to reduce the infiltration of water and oxygen into the open pit walls by placing non-PAG rock and overburden on the open pit walls once mining is completed for an open pit wall section in question and people operating equipment have moved at least 100 m away from proposed backfilling operation. Furthermore, this non-PAG material is expected to provide a permanent high neutralization potential (NP) water source to prevent ARD generation from PAG material present in the open pit walls; and
- Provide annual reports to BC MEMLI and BC MECCS and designated Indigenous groups summarizing the results of geochemical testing.

The following mitigation measures for minimizing potential metal leaching:

- Progressive reclamation will be undertaken to reduce the infiltration of water and oxygen into the non-PAG backfills, buttresses, and embankments;
- Non-PAG rock will be covered with overburden as much as material constraints allow to reduce the infiltration of water and oxygen;
- Place some non-PAG rock into management ponds that are characterized as PAG because of the mine planning process using a neutralization potential ratio (NPR) value of 2NP (neutralizing potential):1AP (acid potential [AP]) to classify non-PAG material from PAG material versus the geochemistry NPR value of 1.2NP:1AP used for classifying non-PAG material from PAG material; and
- In the Post-closure Phase, approximately half of non-PAG material will be flooded with water in the open pit to prevent oxygen ingress and further oxidization of this material resulting in a reduction of metal leaching once this occurs.

5.3.6 People, Employees, Contractors, and Onsite Policies

The following applies to people, employees, and onsite policies:

- Establish and implement an onsite policy prohibiting alcohol consumption, smoking, vaping, and drug use;
- Establish and implement an onsite policy prohibiting shooting, hunting, and fishing within the Project Area. This is expected to further reduce potential exposures of people to COPCs in subsistence foods potentially present at higher concentrations within the Minesite;
- Establish an Indigenous Cultural Awareness Induction program for employees, visitors, and contractors in collaboration with the Wet’suwet’en; and

- Establish and implement policies to promote: no workplace harassment of any kind; environmental protection and awareness; whistle blower protection; health, safety, and security; and multicultural and multi-generational workforce considerations.

5.3.7 Public Access Management

Per the *Mines Act*, RSBC 1996, c 293 (GovBC 1996b) and *Land Act,* RSBC 1996, c 245 (GovBC 1996a) requirements, a "No Unauthorized Entry, Hunting, and Fishing" boundary will be established at the outset of the Construction Phase around the Project Area to prevent unauthorized access. It will be in effect throughout the Project life. This is expected to help minimize potential exposures of people to COPCs that may be present at higher concentrations within the Minesite.

It is currently envisioned that the public will be allowed access through and beyond the Project Area to reach identified cultural, subsistence foods, ceremonial, recreational and hunting areas during the Construction, Operation, Decommissioning and Reclamation, and Post-closure phases, the following will apply to the management of public access:

- Establishing a **PAMP** to mitigate potential safety issues related to public access to/through the Project Area. The **PAMP** was developed for the purpose of public, contractor, visitor, and employee safety, and Project security. The **PAMP** aims to minimize restricted areas and provide opportunities for reasonable and safe access to areas adjacent to and beyond "No Unauthorized Entry, Hunting and Fishing" boundary areas;
- The Wet'suwet'en will be engaged regarding the final implementation of the **PAMP**;
- The **PAMP** includes details on an access control procedure to maintain public access through the Project Area to allow access to recreational locations. Two (2) types of access will be provided:
  - Escorted Access: TCL will provide guided access via operation of a lead vehicle to escort users of the Project Area roads from either the TCL office in Telkwa, or from the Sandpit Muster Station just south of the TAC to the TCRC; TCL will also escort vehicles from the above two locations across the bridge constructed over Goathorn Creek to a parking area on the west side of Goathorn Creek;
  - No-Escort Access: From the parking area near the TCRC, a new trail will be established along the east side of Goathorn Creek that can be used by hikers, horseback riders, bikers, and approved motorized use such as quads, trucks, cars, SUVs and motorbikes, but not including campers. This trail will allow access underneath the TAC via a dedicated public underpass to get to the south side of the TAC. From there the public will be able to use a trail that accesses a divided two (2)-lane bridge installed over Goathorn Creek that allows them to be separated from Project vehicles. After users cross the Goathorn Creek, an existing access trail on the west side of Goathorn Creek can be used as an alternate access trail to Hunter Basin and other recreational sites. Alternately, from Parking Area 2, vehicles will be able to access this same alternate trail on the east side of the Project to recreational areas. Additional details and maps are provided in the **PAMP**;
- With the **PAMP** in place, the Project will improve legal access to recreational facilities via the re-establishment of a bridge over Goathorn Creek;
- Access to the Project Area by the Wet'suwet'en for land use and resource harvesting purposes, will be discussed with the Wet'suwet'en, and facilitated provided that safe access can be accommodated; and
- Tenure holders that overlap with the Project Area will continue to be consulted through the Construction, and Operation phases to consider how operational plans can incorporate other land uses with the results being reported to BC FLNRORD on an annual basis.

5.3.8 Vehicle and Equipment Fleet Selection and Maintenance

Vehicles and equipment will be purchased that meet regulatory air emission standards. A fleet maintenance program will be implemented to support optimal operation of vehicles and equipment. Deficiencies will be corrected and worn parts replaced as soon as practicable. This mitigation measure is intended to minimize emissions of CACs and greenhouse gases (GHGs) but is also expected to minimize noise.

5.3.9 Wood or Oil Stove Replacement Program

To partially offset any potential regional air quality effects associated with the Project, TCL intends to provide a funding program to assist personnel to replace their wood or oil burning stoves with alternative lower emission or higher efficiency heating systems. This mitigation measure aligns with the Bulkley Valley Lakes District (BLVD) Airshed Management Plan: A Community Action Plan for Clean Air (BVLD 2012).

5.3.10 Dust Suppression and Air Emissions

Dust generation and subsequent deposition on exposed soils and plants because of Project activities will be limited through dust suppression techniques and implementation of the **AQMP** The primary approach to reducing road dust re-entrainment within the Project footprint is watering when conditions require. If required alternative and additional. approaches include chemical agent application, such as calcium chloride, designed to alter the surface of the roadway, cementing loose material into a hardened surface. Air emissions will be reduced to the extent practical through implementation of the **AQMP** and the **MTCP**.

5.3.11 Erosion and Sediment Control

Sediment and erosion control measures will be implemented in accordance with the **SEPSCP** and **CEMP**.

Areas prone to instability and areas in proximity to water bodies and drainages will be further reinforced/stabilized via construction of abutments and permanent erosion controls, if specified. Hydrological connectivity will be maintained by providing unobstructed passage of water in existing drainage channels through fill materials (i.e., using free-span bridges or culverts at water crossings) in accordance with the **MWMP**.

5.3.12 Spill Prevention and Response

Spill prevention and response measures will be implemented during vehicle and equipment travel/operations in accordance with the **FMSCP** and any hazardous materials management in accordance with the **FMSCP** as well. This is expected to limit potential effects on drinking water quality and vegetation quality and thus will limit potential effects on subsistence foods (vegetation tissue) quality.

5.3.13 Management of Hazardous Materials and Wildlife Attractants

The following applies to management of Project emissions and discharges with potential to affect wildlife to limit effects on subsistence foods (wildlife tissue) quality:

- The use of harmful and hazardous substances will be limited to the extent practical;
- Hazardous materials will be handled and stored using measures, such as those in the **FMSCP** and **WMPRE**, to avoid attracting wildlife (e.g., wildlife proof containers or exclusion fencing);
- The use of road salts within the Project Area will be minimized to reduce attractants to wildlife;
- Vegetation management will be incorporated within the Project Area and adjacent to management, sedimentation, and control ponds to minimize site attractiveness to wildlife;

- Visual and auditory deterrents will be used to deter wildlife from using potentially contaminated areas such as the Soil Treatment Facility; and
- A "No Littering" policy within the Project Area will be implemented;
- Any materials that could act as wildlife attractants (e.g., oils, chemicals, garbage) will be placed, stored, and stockpiled in either animal proof containers or in a manner that minimizes their potential to attract wildlife. If evidence of wildlife presence or access to waste disposal facilities or a waste disposal compliance problem is detected, use of modified systems and/or increase of offsite waste disposal frequencies will be implemented; and
- Management of waste and/or wildlife attractants will be included in the Wildlife Education Program (refer to **WMP**).

5.3.14 Summary of Mitigation Measures

A summary of the mitigation measures proposed by TCL to avoid or reduce potential Project-related adverse effects on Human Health, and whether or not a residual effect is anticipated, is provided in **Table 5.3-1.**

Table 5.3-1: Summary of Potential Effects and Mitigation Measures for the Human Health Valued Component (VC)

Potential Effect	Contributing Activities* within the Project Phases (C, O, D, P)	Proposed Mitigation Measure	Residual Effect (Yes/No)
Change in Human Health due to Changes in Air Quality (CACs)	All activities generating emissions (O)	▪ Limit Project footprint and Project Area ▪ Reclamation measures (refer to **RCP**) ▪ Transport measures ▪ Blasting measures (refer to **EMP**) ▪ Vehicle and equipment fleet selection and maintenance (refer to **AQMP)** ▪ Dust suppression and air emissions (refer to **AQMP**, **MTCP**) ▪ Wood or oil stove replacement program	Yes
Change in Human Health due to Changes in Environmental Media Quality	All activities generating emissions and effluents (C, O, D, P)	▪ Limit Project footprint and Project Area ▪ Reclamation measures (refer to **RCP**) ▪ Transport measures ▪ Blasting measures (refer to **EMP**) ▪ People, employees, contractors, and onsite policies ▪ Public access management (refer to **PAMP**) ▪ Dust suppression and air emissions (refer to **AQMP**, **MTCP**) ▪ Erosion and sediment control (refer to **SEPSCP, CEMP**, and **MWMP**) ▪ Management of ML/ARD (refer to **ML/ARDMP**) ▪ Spill prevention and response (refer to **FMSCP**) ▪ Management of hazardous materials and wildlife attractants (refer to **FMSCP** and **WMPRE** and **WMP**)	Yes
Change in Human Health due to Changes in Noise	All activities generating noise (O)	▪ Limit Project footprint and Project Area ▪ Transport measures ▪ Blasting measures (refer to **EMP**)	Yes

Potential Effect	Contributing Activities* within the Project Phases (C, O, D, P)	Proposed Mitigation Measure	Residual Effect (Yes/No)
		▪ Vehicle and equipment fleet selection and maintenance (refer to **AQMP**)	

Notes: *C, O, D, P represent Project Phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure AQMP=Air Quality Management Plan (S13.0-C1); CEMP=Construction Environmental Management Plan (S13.0-C4); EMP=Explosives Management Plan (S13.0-C6); FMSCP=Fuel Management and Spill Control Plan (S13.0-C7); MTCP=Minesite Traffic Control Plan (S13.0-C10); MWMP=Minesite Water Management Plan (S13.0-C11); ML/ARD=metal leaching/acid rock drainage; ML/ARDMP=Metal Leaching (ML)/Acid Rock Drainage (ARD) Management Plan (S13.0-C12); PAMP=Public Access Management Plan (S13.0-C14); RCP=Reclamation and Closure Plan (S13.0-C15); SEPSCP=Surface Erosion Prevention and Sediment Control Plan (S13.0-C17); WMPRE=Waste Management Plan for Refuse and Emissions (S13.0-C20); WMP=Wildlife Management Plan (S13.0- C21).*
Please refer to **Table 5.1-2 for list of applicable activities for each listed Project phase, unless otherwise noted in this table.*

5.4 Residual Effects and Significance of Residual Effects

This subsection describes predicted residual effects of the Project on the Human Health VC. Residual effects are the adverse Project effects that remain after the implementation of all mitigation measures and management strategies and are the expected consequences of the Project on the Human Health VC. The evaluation of residual effects on Human Health relies on the evaluation of potential risks from exposure to COPCs from the **HHRA**, provided in **Appendix 8.0-A**, and the evaluation of noise effects in **S4.0-C1 Atmospheric Environment VC**.

5.4.1 Assessment Methodology

Residual effects for Human Health from incremental changes in CAC and environmental COPC concentrations due to the Project are derived from CRs (for CACs) and HQs and ILCRs (for COPCs) calculated in the HHRA, as already described for the Base Case risks in **4.1.3**. The HHRA followed guidance for conducting HHRAs in the context of environmental effects assessment (Northern Health 2015a; Health Canada 2016a, 2016b, 2018, 2019; BC MOH 2021).

Characterisation of residual effects for Human Health from changes in noise levels during the Operation Phase are based on quantitative model results in **S4.0-C1** and **Appendix 4.1-A Noise Modelling Report** and describing effects on sleep disturbance, interference with communication, and complaints and level of annoyance.

The **HHRA** (**Appendix 8.0-A**) included three (3) scenarios:

- Base Case (see **4.2**): conditions prior to Project development, including measured or predicted concentrations of parameters in exposure media (i.e., air, water, soil, or food). The Base Case relied on measured or modelled Base Case data for concentrations of COPCs in surface water, groundwater, dust, soil, vegetation, and fish tissue to estimate the level of risk to Human Health from exposure to COPCs under existing or Base Case conditions. The Base Case also included modelling of COPC concentrations in subsistence foods from uptake of COPCs in water, soil and food, including large mammals (represented by moose, deer, and bear), small mammals (represented by snowshoe hare), and birds (represented by grouse; Attachment D of **Appendix 8.0-A**);
- Project Case (Operation): future conditions scenario that considered the Construction and Operation phases, including predicted concentrations of COPCs in exposure media following Project development;

- Project Case (Closure): future conditions scenario that included both Decommissioning and Reclamation and Post-closure, including predicted concentrations of COPCs in exposure media following Project development; and
  - The Project Case (Operation) and Project Case (Closure) relied on predictive modelling for air quality (**S4.0-C1, Appendix 4.1-B Air Quality Modelling Report**; **Attachment A** to **Appendix 8.0-A**), surface water quality (**Appendix 4.3-A Tenas Project - Water and Load Balance Modeling Report**), soil quality (Attachment A of **Appendix 8.0-A**), vegetation tissue quality (**Attachment A** of **Appendix 8.0-A**), and fish tissue quality (**Attachment A** of **Appendix 8.0-A**) quality. The same food chain model (**Attachment D** of **Appendix 8.0-A**) used in the Base Case for prediction of subsistence foods tissue quality was used in both Project Cases, except that predicted concentrations of COPCs in water, soil, and food were used as inputs rather than Base Case concentrations.

As recommended by the BC MOH (2021) and Health Canada (Health Canada 2018, 2019), both the Base Case and Project Case included an estimate of risk from intake of market foods (i.e., foods available from retail or commercial sources; **Attachment E** of **Appendix 8.0-A**). The intake of market foods and associated risk was assumed to be the same in both cases and contributes to background (outside of the LSA) exposures of people to COPCs.

By comparing the risk estimates (CRs, HQs or ILCRs) from the Base Case and Project Case HHRA, the incremental change in risk to Human Health due to the Project can be identified so that the Project-related residual effects from exposure to COPCs can be characterized. The HHRA calculated risk estimates for each COPCs in both the Base Case and Project Case for non-carcinogens (HQs, for all 18 COPCs) or carcinogens (ICLRs for arsenic via the ingestion exposure route and for arsenic, cadmium, chromium, and nickel via the inhalation exposure route) for Recreational Land Users and Indigenous and non-Indigenous Resident land Users in the LSA.

5.4.1.1 Residual Effects Characteristics

Project-related residual effects were characterised based on the risk estimates and using the criteria and definitions outlined in **Table 5.4-1.**

Table 5.4-1: Definitions of Effect Characteristics Ratings Considered when Determining the Significance of Residual Effects on Human Health

Residual Effect Characteristic	Definition	Rating
Magnitude	Size or severity of the residual effect	For CR and HQs: **Low**: Greater than acceptable threshold but incremental change is less than 20% [2]. **Moderate**: Greater than acceptable threshold, incremental change is equal to or greater than 20% but is within the range of uncertainty for effects on Human Health. **High**: Greater than acceptable threshold, incremental change is equal to or greater than 20% and is outside of the range of uncertainty for effects on Human Health. For ILCRs: **Low**: Project-Only ILCR is greater than acceptable threshold but is more than 10 times lower than non- Project contributions to total ILCR (e.g., from store-bought foods).

[2] This percentage is based on the recommended value for relative percent difference (RPD) for duplicate samples from BC MOE (2013). Values below 20% would not be measurable as they are within the magnitude for natural variability.

Residual Effect Characteristic	Definition	Rating
		Moderate: Project-Only ILCR is greater than acceptable threshold but is less than or equal to 10 times lower than non-Project contributions to total ILCR. **High**: Project-Only ILCR is greater than acceptable threshold and is higher than non-Project contributions to total ILCR. <u>For Noise:</u> **Low**: Project noise levels are within Base Case levels and within health-based thresholds for %HA and sleep disturbance. **Moderate**: Project noise levels are equal to or higher than Base Case and are higher than health-based thresholds for sleep disturbance, but within threshold for %HA. **High**: Project noise levels are higher than Base Case and are higher than health-based thresholds for sleep disturbance and higher than threshold for %HA.
Geographic Extent	Spatial scale over which the residual effect is expected to occur.	**Local:** limited to a portion of the LSA or all of the LSA. **Regional**: limited to a portion of the RSA or all of the RSA. **Beyond Regional**: Beyond the RSA.
Duration	Length of time over which the residual effect is expected to persist.	<u>For CRs, HQs, and ILCRs:</u> **Short-term:** From months to 20 years **Medium-term:** Between 20 and 50 years **Long-term**: Over the lifetime of a person (50 years or longer) <u>For Noise</u>: **Short-term:** Effects are not evident beyond the Construction Phase. **Medium-term:** Effects are not evident beyond the life of the Project. **Long-term:** Effects will persist beyond the life of the Project.
Frequency	How often the residual effect is expected to occur.	**Infrequent:** Effects are sporadic, occurring at irregular intervals. **Frequent:** Effects occur on a regular basis, at regular intervals. **Continuous:** Effects occur near-continuously or continuously.
Reversibility	Whether or not the residual effect can be reversed once the activity causing the residual effect ceases.	**Fully Reversible:** Effects will diminish to Base Case conditions. **Partially Reversible:** Effects will partially diminish to Base Case conditions. **Irreversible:** Effects are permanent and will not diminish to Base Case conditions.
Context	The extent to which Human Health has been affected by past and present environmental and socio-economic processes and conditions, its potential sensitivity to the Project-related residual effect, and its ability to recover from	**Low**: Limited extent of effect by other conditions, low sensitivity, and high resiliency **Moderate**: Moderate extent of effect by other conditions, moderate sensitivity, and moderate resiliency **High**: Large extent of effect by other conditions, high sensitivity, and low resiliency

Residual Effect Characteristic	Definition	Rating
	that effect (i.e., resilience)	

Notes: *%=percent; %HA=percent highly annoyed; CR=concentration ratio; HQ=hazard quotient; ILCR=incremental lifetime cancer risk; LSA=Local Study Area; RSA=Regional Study Area*

5.4.1.2 Likelihood

Likelihood considers the probability that the residual effect will occur, including consideration of the likelihood that the mitigation will be successful.

- **Unlikely** Low probability of an effect, or
- **Likely** Moderate-to-High probability of an effect.

5.4.1.3 Significance

The residual effects characterisation (see **5.4.1.1**) and associated prediction in changes to the measurement indicators provide the foundation for the determination of Significance. The characterisation of residual effects is based on the review of existing conditions (see **4.0**) and the assessment of Project-related effects (see **5.4**). All residual effects (independent of their Significance rating) are carried forward to the CEA.

The Significance of the residual effect is rated as **Not Significant** or **Significant**, based on the following:

Significant An effect that results in a change in Human Health within the RSA that will alter its integrity beyond an acceptable level, generally defined as High Magnitude effects, Regional or greater in Extent, with a Long-term Duration; or

Not Significant An effect that does not meet the definition of Significant.

Confidence is a measure of how well residual effects are understood and the quality of the input data. It considers the scientific certainty relative to the quantification and/or qualification of the effect, including the quality and or quantity of data and the understanding of effect mechanisms, as well as professional judgment based on prior experience in predicting effects and the effectiveness of mitigation measures. A Low Level of Confidence is assigned to effects predictions with little or no empirical site-specific data, whereas a Moderate Level of Confidence is assigned to predictions that are based on site-specific data sources such as predictive model outputs and published literature. A High Level of Confidence is assigned to predictions that have direct, site-specific quantitative data to support the predictions.

5.4.2 Residual Effects on Human Health due to Changes in Air Quality (Criteria Air Contaminants [CACs])

While Project contributions to maximum predicted concentrations of PM, NO_2 and dustfall may exceed ambient air quality criteria in a small area at and southeast of the Minesite and CPP (see **S4.0-C1**), it is highly unlikely that land users will spend any substantial amount of time in this location[3]. Therefore, potential effects on Human Health from inhalation of NO_2, SO_2, and dustfall were not expected and therefore not carried forward in the HHRA.

The assessment of residual effects from changes in air quality on Human Health focussed on the Operation Phase. Effects during the Construction, Decommissioning and Reclamation, and Post-closure phases are expected to be lower than effects during the Operation Phase, and are effectively captured through the assessment of the Operation Phase.

Maximum predicted concentrations for all CACs and all averaging periods are expected to remain below the relevant ambient air quality criteria at sensitive receptor locations including the TCRC and nearby residences (**Table 3.4-4** in **Appendix 8.0-A**).

Based on the maximum concentration exceeding guidelines in Telkwa, PM_{10} and $PM_{2.5}$ were selected as CACs of concern to Human Health in the HHRA (**Appendix 8.0-A**). In the populated area of Telkwa, maximum predicted concentrations of PM_{10} and $PM_{2.5}$ may exceed the ambient air quality criteria due to high background concentrations; however, the Project-only contribution is very low, making up less than 5% of background PM_{10} and $PM_{2.5}$ concentrations.

Based on background PM_{10} and $PM_{2.5}$ and applicable guidelines, Base Case CRs exceed the health-based CR threshold of 1 in Telkwa (**Table 5.4-2**), but not at the TCRC or rural residences. Project contributions alone contribute very little to an increase in the CRs in Telkwa during Operation, from a CR of 1.36 to 1.38 (24-hour average $PM_{2.5}$) or from 1.34 to 1.41 (annual average $PM_{2.5}$), or less than 5% overall. The CR for PM_{10} during Operation is 1.16, with 0.03 contributed by the Project. The magnitude of change is unlikely to be detectable given inter-annual variability in PM concentrations.

[3] The **Public Access Management Plan (S13.0-C14**) (**PAMP)**; indicates that certain areas of the Project Property will be designated as "No Hunting" as stated in the *Wildlife Act*, RSBC 1996, c 488 (GovBC 1996c), and "No Unauthorized Entry" under the BC *Mines Act*, RSBC 1996, c 293 (GovBC 1996b), and *Land Act*, RSBC 1996, c 245 (GovBC 1996a). This will affect some current trails (motorized and non-motorized recreational use) and access points that fall within the Project's planned development area. From the TCRC, TCL will establish a trail along the east side of Goathorn Creek that will be a multiuse trail for hikers, bikers, motorized use and horseback riders and ultimately provide access to Hunter Basin. This restricts access to the Project development area by the general public.

Table 5.4-2: Concentration Ratios for Criteria Air Contaminants (CACs) at Receptor Locations in the Base Case and Project Case (Operation)

CAC	Averaging Period	Telkwa	TCRC	Rural Residence
Maximum CR for Project Contribution				
PM_{10}	24-hour	0.03	0.50	0.22
$PM_{2.5}$	24-hour	0.02	0.17	0.09
	Annual	0.01	0.06	0.05
Maximum CR for Project plus Background				
PM_{10}	24-hour	**1.16**	0.80	0.52
$PM_{2.5}$	24-hour	**1.38**	0.58	0.50
	Annual	**1.41**	0.41	0.40
CAC	Averaging Period	BC ENV- Telkwa	PM-PPR2	Rural Residence
Minimum CR for Base Case				
PM_{10}	24-hour	n/a	0.11	n/a
$PM_{2.5}$	24-hour	**1.36**	0.17	n/a
	Annual	**1.34**	0.27	n/a

Notes: Telkwa**=**sensitive receptor locations within the Village of Telkwa in the air quality model domain.
*BC ENV Telkwa=BC Ministry of Environment and Climate Change Strategy ambient air quality monitoring station; CAC=criteria air contaminant; CR=concentration ratio; n/a=not applicable, no measurement available for Base Case (see **Tables 3.4-1** and **3.4-2** in **Appendix 8.0-A**), and **Appendix 4.1-C** in **S4.0-C1;** TCRC=Telkwa Coalmine Recreation Camp*
Bold numbers indicate a CR higher than the acceptable threshold of 1.
*For more information about PPR2, see **Appendix 8.0-A Human Health Risk Assessment (HHRA).***

Based on the CRs and the analysis of potential risks from exposure to CACs at receptor locations presented in the preceding paragraphs (with additional detail provided in Section 6.2 of **Appendix 8.0-A**), a residual effect to Human Health is predicted (i.e., the Project-related incremental change is not zero and CR is greater than 1) for residents of Telkwa. However, no effects on Human Health are predicted for Recreational and Resident Land Users.

5.4.2.1 Residual Effect Characteristics

Characterisation of residual effects for Human Health from changes in concentrations of PM_{10} and $PM_{2.5}$ includes an assessment of Magnitude, Geographic Extent, Duration, Frequency, Reversibility, and Context, based on the definitions for each criterion provided in **Table 5.4-1** of this chapter and **5.4.1 of the Assessment Methodology (S3.0-C6)**. The ratings for residual effects on Human Health from exposure to parameters of concern are summarized in **Table 5.4-3,** with the rationale for the ratings provided in the third column of the table.

Table 5.4-3: Summary of Effect Characteristics Ratings for Changes in Air Quality (Criteria Air Contaminants [CACs])

Residual Effects Characteristic	Rating	Rationale for Rating
Magnitude	Low	The maximum incremental increase in CR in Telkwa, the TCRC, and rural residences for annual average PM_{10} and annual- and 24-hour average $PM_{2.5}$ due to Project emissions are less than 5%. Project CRs are substantially less than the threshold of 1 at the TCRC or rural residences. The threshold of 1 is exceeded in Telkwa already under existing Base Case conditions and the predicted increase in CR is less than 5%, based on comparison with regulatory guidelines.
Geographic Extent	Local	Effects are limited to the LSA.
Duration	Medium-term	Effects are anticipated for the duration of the Project and cease after the Decommissioning and Reclamation Phase.
Frequency	Frequent	While Project activities contributing to PM_{10} and $PM_{2.5}$ emissions are anticipated to be continuous or near-continuous, residual effects on Human Health are more likely to occur in winter when background PM_{10} and $PM_{2.5}$ concentrations are higher.
Reversibility	Fully Reversible	Since the Magnitude is Low and the residual effect is not expected to be detectably different than the Base Case, any effects are likely to be fully reversible.
Context	Low	People have varying degrees of sensitivity and ability to adapt to stressors, depending on several other non-biophysical factors that also influence overall human health. Existing air quality in Telkwa results in calculated CRs > 1 for annual- and 24-hour average $PM_{2.5}$.and resiliency to existing conditions is considered high.

Notes: *>=greater than; %=percent; CR=concentration ratio; LSA= LSA=Local Study Area;* $PM_{2.5}$*=particulate matter with diameter equal to or less than 2.5 micrometre (μm)* PM_{10}*=particulate matter with diameter equal to or less than 10 micrometre (μm); Project=Tenas Project; TCRC=Telkwa Coalmine Recreation Camp*

5.4.2.2 Likelihood

Residual effects on Human Health due to changes in Project-related contributions of $PM_{2.5}$ and PM_{10} are considered **Unlikely** since the associated CRs are less than the threshold or, when already above the threshold in the Base Case (in Telkwa), the increase in the CR due to the Project is less than 5% and unlikely to be measurable given inter-annual variability in $PM_{2.5}$ and PM_{10} concentrations.

5.4.2.3 Significance Determination

The residual effect of change in Human Health from change in Air Quality (CACs) as a result of the Project is not expected to alter its integrity within the Human Health LSA to an unacceptable level; the effect is predicted to be of Low Magnitude, Local Extent, Medium-term Duration, and Fully Reversible. Therefore, the effect of change in Human Health is predicted to be **Not Significant.**

The Level of Confidence is **High** as a quantitative assessment and modelling were completed using Project-specific and receptor-specific information where possible.

5.4.3 Residual Effects on Human Health from Changes in Environmental Media Quality

5.4.3.1 Recreational Land User

5.4.3.1.1 Residual Effects from Non-carcinogenic Contaminants of Potential Concern (COPC)

Table 5.4-4 shows total HQs for Recreational Land Users for the Base Case, Project Case, and the incremental change between Base Case and Project Case in percent for both toddlers (considered to be the most sensitive life stage) and adults. As described in **5.4**, Project Case included both a Project Case (Operation Phase scenario which considered Construction, and Operation phases, as well as a Project Case [Post-closure Phase]) scenario which considered Decommissioning and Reclamation, and Post-closure phases.

For Recreational Land Users, an HQ threshold of 0.2 was used to define the acceptable risk since not all background exposures (i.e., exposures that occur while outside of the LSA such as from air, drinking water, or soil) were included in the HHRA (Health Canada 2019; BC MOH 2021). HQs for individual exposure pathways are presented in Attachment G of **Appendix 8.0-A**.

Table 5.4-4: Total Hazard Quotients in the Base Case, Project Case (Operation), and Project Case (Closure), and Incremental Change between the Base Case and Project Case for Contaminants of Potential Concern (COPCs)

Contaminant of Potential Concern (COPC)	Recreational Land User Toddler[1]					Indigenous and non-Indigenous Resident Land User Toddler[2]					Recreational Land User Adult[1]					Indigenous and non-Indigenous Resident Land User Adult[2]				
	Base Case	Operation	Closure	%X OP	%X CL	Base Case	Operation	Closure	%X OP	%X CL	Base Case	Operation	Closure	%X OP	%X CL	Base Case	Operation	Closure	%X OP	%X CL
Aluminum	**0.29**	**0.29**	**0.30**	-1%	1%	0.58	0.57	0.58	-2%	1%	0.100	0.099	0.10	0%	2%	0.12	0.12	0.12	0%	2%
Arsenic	**11**	**11**	**11**	0%	0%	**11**	**11**	**11**	0%	0%	**3.5**	**3.5**	**3.5**	0%	0%	**3.6**	**3.6**	**3.6**	0%	1%
Barium	0.17	0.17	0.17	0%	0%	0.20	0.20	0.20	0%	0%	0.064	0.064	0.064	0%	0%	0.080	0.081	0.080	0%	0%
Boron	0.0069	0.013	0.014	**94%**	**109%**	0.030	0.037	0.038	**23%**	**29%**	0.0032	0.0062	0.0068	**93%**	**111%**	0.016	0.019	0.020	19%	**25%**
Cadmium	**1.1**	**1.1**	**1.1**	0%	3%	**1.1**	**1.1**	**1.1**	0%	3%	**0.45**	**0.45**	**0.46**	0%	3%	0.45	0.46	0.47	0%	3%
Chromium	**0.54**	**0.55**	**0.55**	1%	2%	0.62	0.63	0.63	1%	2%	**0.23**	**0.23**	**0.23**	1%	2%	0.25	0.25	0.25	1%	2%
Cobalt	**0.44**	**0.44**	**0.52**	2%	18%	0.49	0.49	0.57	2%	18%	0.18	0.18	**0.22**	2%	**21%**	0.19	0.19	0.23	2%	**22%**
Iron	**0.71**	**0.72**	**0.72**	2%	1%	0.93	0.95	0.94	2%	1%	**0.29**	**0.29**	**0.29**	2%	1%	0.30	0.31	0.31	2%	1%
Lithium	**0.72**	**0.76**	**0.95**	6%	**33%**	0.79	0.84	**1.1**	5%	**38%**	**0.29**	**0.31**	**0.41**	7%	**41%**	0.32	0.34	0.47	6%	**49%**
Manganese	**8.5**	**8.5**	**8.6**	0%	1%	**9.0**	**9.0**	**9.1**	0%	1%	**3.4**	**3.4**	**3.5**	0%	2%	**3.6**	**3.6**	**3.7**	0%	1%
Mercury	**0.73**	**0.81**	**0.79**	11%	9%	0.73	0.82	0.80	12%	10%	**0.27**	**0.31**	**0.30**	14%	12%	0.27	0.31	0.30	15%	12%
Molybdenum	**2.2**	**2.2**	**2.2**	0%	1%	**2.2**	**2.2**	**2.2**	0%	1%	**0.86**	**0.87**	**0.87**	0%	1%	0.87	0.87	0.88	0%	1%
Nickel	**10**	**10**	**10**	1%	1%	**10**	**11**	**11**	1%	1%	**4.5**	**4.6**	**4.6**	1%	1%	**4.6**	**4.6**	**4.6**	1%	1%
Selenium	**0.86**	**0.98**	**0.98**	14%	14%	0.86	0.99	0.99	14%	15%	**0.39**	**0.44**	**0.45**	15%	16%	0.39	0.45	0.45	15%	16%
Strontium	0.072	0.074	0.078	3%	8%	0.086	0.089	0.10	4%	19%	0.033	0.034	0.036	3%	9%	0.041	0.042	0.050	4%	**22%**
Thallium	0.41	0.52	0.92	**28%**	**126%**	0.41	0.54	**1.0**	31%	**146%**	**0.58**	**0.76**	**1.4**	**32%**	**145%**	0.59	0.78	**1.6**	**34%**	**173%**
Zinc	**0.94**	**0.95**	**0.95**	0%	1%	0.95	0.95	0.96	0%	1%	**0.33**	**0.33**	**0.34**	0%	1%	0.33	0.34	0.34	0%	1%

Notes: *%X CL=Incremental percent change between the Base Case and Project Case (Closure); %X OP=Incremental percent change between the Base Case and Project Case (Operation)*
[1] Hazard quotients greater than 0.2 are bolded and shaded grey.
[2] Hazard quotients greater than 1 are bolded and shaded grey.
Incremental percent change of >20% for %X OP and %X CL is bolded and shaded grey.
*Hazard quotients for each exposure pathway are presented in Appendix G of **Appendix 8.0-A**.*

The following 14 COPCs had a HQ greater than 0.2 for the Recreational Land Users toddler in the Base Case: aluminum, arsenic, cadmium, chromium, cobalt, iron, lithium, manganese, molybdenum, mercury, nickel, selenium, thallium, and zinc. The same parameters were predicted to be higher than the HQ threshold of 0.2 in the Project Cases. Except for aluminum and cobalt, the same COPCs (12) were higher than the HQ threshold in the Base Case and Project Case (Operation), and all COPCs except aluminum were higher than the HQ threshold in Project Case (Closure[4]) for the Recreational Land Users adult.

For inhalation, ingestion of drinking water, incidental ingestion of soil, and dermal contact with soil, HQs for the individual exposure routes were low and no COPCs had HQs higher than 0.2 in any of these individual exposure routes in either the Base Case or Project Case.

HQs for the ingestion of market foods were above 0.2 for all of the COPCs with total HQs higher than 0.2. Arsenic had the highest calculated HQ of 11 (toddler) and 3.5 (adult) in both the Base Case and Project Case, where essentially all of the total HQ came from ingestion of market foods; the next highest HQ for an exposure route (ingestion of subsistence foods) for arsenic was 200 times lower. However, because the risk (HQ) from consumption of market foods does not change between the Base Case and Project Case (i.e., Project-related incremental change is zero for market foods), it is not the focus of the risk or residual effects characterisation.

Ingestion of subsistence foods in the Base Case for Recreational Land Users also had HQs above 0.2 for nickel (toddler and adults); see Attachment G of **Appendix 8.0-A**. However, the HQs from other exposure pathways including inhalation, ingestion of drinking water, incidental ingestion of soil were negligible (generally, more than 10 to 10,000 times lower) compared to subsistence foods and/or market foods ingestion. In the Project Case, the HQ for some COPCs in addition to nickel increased above the 0.2 threshold for Recreational Land Users as follows: for adults, thallium increased above the threshold in Operation, and Closure phases; for toddlers, manganese increased above the threshold in Operation Phase and lithium, manganese, and thallium increased above the threshold in Closure.

The HQs for the majority of COPCs did not change significantly (less than 20% incremental change; **Table 5.4-4**) between the Base Case and Project Case for Recreational Land Users, except for boron (greater than 100% increase), lithium (about 40% increase), and thallium (about 150% increase; all increases quoted for the Project Case [Closure] scenario). Hazard quotients for cobalt were below 20% incremental change except for an increase by 21% for the adult in Closure only. An incremental change in HQ of less than 20% can be considered not significant as it is within the range of variability and margin of error of measurable COPCs concentrations in air, water, soil, and foods and is unlikely to be detectable in environmental monitoring programs. In addition, given the conservative assumptions used in the risk assessment (e.g., all subsistence foods eaten by a person in a year come from within the LSA, small TRVs due to safety factors of up to 1,000 fold), environmental media variability, and the inherent uncertainties in risk assessment, for the COPCs where the HQ was higher than 0.2 but the Project-related incremental change in HQ was less than 20%, measurable changes in Human Health due to the Project are unlikely.

Although the incremental increase in HQs for boron was predicted to be greater than 100% in the Project Case (Closure), the total HQs remained below the threshold of 0.2 for both the Base Case and Project Case (**Table 5.4-4**). Thus, it is concluded that exposure to boron does not pose a health risk to human

[4] In the **HHRA (Appendix 8.0-A)** Construction and Operation phases were combined into risk estimates for the Project Case (Operation) scenario, while the Decommissioning and Reclamation phase and the Post-closure phase were combined into risk estimates for the Project Case (Closure) scenario.

Recreational Land Users. The incremental increase is a result of small, predicted increases in concentrations of boron in surface water and soil.

Increases in total HQ for cobalt and lithium in the Project Case (Closure) scenario were due to a doubling in predicted HQs for these COPCs in subsistence foods, especially rainbow trout. This is due to a predicted increase in cobalt and lithium concentrations in surface water in the Decommissioning and Reclamation Phase. Drinking water HQs for cobalt and lithium remain below the threshold HQ of 0.2. The HQs from ingestion of market foods are generally in the same order of magnitude compared to risks from eating subsistence foods for these COPCs. Therefore, it is unlikely that the predicted increases in HQs will result in measurable effects on Recreational Land Users. Nevertheless, cobalt and lithium should be included in future monitoring programs to confirm that future measured concentrations remain within the range predicted in surface waters and fish tissues.

The incremental increase in total HQ for thallium in the Project Case (Operation) and Project Case (Closure) scenarios are due to ingestion of thallium from surface water and subsistence foods, especially rainbow trout (**Table 4.3-10** to **Table 4.3-12** in **Appendix 8.0-A**). Thallium concentration is predicted to increase in fish tissues because thallium concentrations are predicted to increase in surface water downstream of the Project. However, drinking water HQs remain below threshold HQs of 0.2 in Project Case and, therefore, drinking water from creeks and streams in the LSA is not predicted to result in health risks to Recreational Land Users.

The level of incremental change in HQs due to ingestion of thallium is not likely to result in measurable effects on Recreational Land Users. This conclusion is based on the following considerations:

- Environment and Climate Change Canada (ECCC) and Health Canada (2020) state that food is the primary source of thallium exposure for the Canadian population. Both market foods and country foods were fully accounted for in the risk calculations for Recreational and Resident land Users and the total HQs for Residents were below the threshold of 1, (except for adults in Closure). Using a HQ threshold of 0.2 for the Recreational Land User is very conservative as the highest contribution to the HQ from background market foods exposures is accounted for and background contributions from air inhalation or contact/ingestion with soil and water are likely insignificant relative to food ingestion;
- Based on partition coefficients for water to suspended particles of 4.28 and for water to sediment of 1.48 (summarized by Harvey et al. 2007), thallium is predicted to be moderately mobile from water to sediment and highly adsorbent to particulate matter in surface water (ECCC and Health Canada 2020). Another mechanism for removing thallium from water is the precipitation of Tl(III) hydroxide followed by reduction to Tl(I) by organic rich anaerobic sediment or bound to sediment with sulfide ion to form insoluble thallium(I) sulfide (International Programme on Chemical Safety 1996; Laforte et al. 2004; Gao et al. 2007; Turner et al. 2010). Thus, thallium may partition from water to sediment indicating that dissolved thallium concentrations, and thus HQs, downstream of the Project are likely over-estimated as these attenuation mechanisms are not included in the surface water quality model;
- The derivation of the Exposure Point Concentration (EPC) for thallium in water in the Closure Phase was highly conservative because the maximum (worst year) thallium concentration was chosen for each phase and each water quality modelling node and then assumed to persist over the entire duration of the phase. However, thallium concentrations vary over time in the Closure Phase, increasing in Year 2045 to Year 2070, and then decreasing at a slower rate until the end of the modelling period. Thus, while thallium concentrations in fish tissues will also vary with time, the highest concentration was assumed to persist throughout the entire Closure Phase and are likely to overestimate actual fish tissue concentrations;

- The percent change in fish thallium concentrations may be unrealistically high between the Base Case and Project Case, as they are modeled based on the change in thallium water concentrations using a linear relationship between water concentration and fish tissue concentration that may overestimate the uptake relationship as uptake rates often have an inverse relationship with water concentrations (McGeer et al. 2003; Carriquiriborde, Handy, and Davies 2004; DeForest, Brix, and Adams 2007; Adams 2011). Thallium uptake and bioaccumulation by aquatic animals and plants, transfer along aquatic food chains, as well as environmental behavior and toxicity of thallium ion species [Tl(III) and Tl(I)] remain poorly understood (Couture et al. 2011); and
- Biomonitoring data from Canada and the United States of America (USA) demonstrate that thallium-containing substances are of low concern at the current levels of exposure found in the general public (ECCC and Health Canada 2020). The conclusion was based on comparing monitoring data of total thallium in urine of the Canadian population to a human biomonitoring guidance value, which is typically derived from existing health-based exposure values (Umweltbundesamt [Federal Environment Agency] 2011). Health Canada stated that food intake is the primary route of exposure to thallium, with an average dietary intake for all age groups of 0.029 µg/kg body weight (bw)-day and for toddlers of 0.088 µg/kg bw-day (based on Health Canada 2011a), and that biomonitoring data of total thallium urinary creatinine adjusted concentrations are more than an order of magnitude below the human biomonitoring guidance value. Based on the foregoing information and on the maximum Project Case total dose of 0.040 µg/kg bw-day for adults and 0.089 µg/kg BW-day for toddlers (for Resident Land Users in Closure), health risks to people from thallium are expected to be negligible.

However, due to the uncertainties in the risk assessment for thallium, thallium should be included in future follow-up programs to confirm that future measured concentrations remain within the range predicted in surface waters and fish tissues.

Based on the HHRA and the analysis of potential risks from exposure to non-carcinogenic COPCs for Recreational Land Users presented in the preceding paragraphs (with additional detail provided in **Appendix 8.0-A**), a residual effect on Human Health is predicted (i.e., the Project-related incremental change is not zero).

5.4.3.1.2 Residual Effects from Carcinogenic Contaminants of Potential Concern (COPCs)

Arsenic, cadmium, chromium, and nickel are the COPCs considered to be carcinogens via the inhalation route. Inhalation ILCRs for arsenic, cadmium, chromium, and nickel were calculated for each life stage and then summed, since all four (4) parameters have the potential to cause lung cancer (i.e., same endpoint). The ILCR for the Project-only Case (incremental change) was calculated as the Project Case ILCR minus the Base Case ILCR. For all human receptors, an ILCR threshold of $1x10^{-5}$ (1 in 100,000) was used to define the acceptable risk for the Project-only Case, as recommended by Health Canada (2019) and BC MOH (2021).

As shown in **Table 5.4-5**, the calculated Project-only ILCR for Recreational Land User adults for carcinogens via the inhalation exposure route is below the acceptable threshold of 1.0×10^{-5}. The ILCR is within acceptable limits and no residual effects on Recreational Land Users are expected from carcinogenic COPCs via the inhalation exposure route.

Table 5.4-5: Incremental Lifetime Cancer Risk (ILCR) via Inhalation for Carcinogenic Contaminants of Potential Concern (COPCs) for Recreational Land Users

	Infant	Toddler	Child	Teen	Adult
Base Case					
Arsenic ILCR	1.3×10^{-08}	6.1×10^{-08}	5.7×10^{-08}	4.3×10^{-08}	1.6×10^{-07}
Cadmium ILCR	1.2×10^{-09}	5.5×10^{-09}	5.1×10^{-09}	3.9×10^{-09}	1.5×10^{-08}
Chromium ILCR	3.5×10^{-08}	1.6×10^{-07}	1.5×10^{-07}	1.1×10^{-07}	4.2×10^{-07}
Nickel ILCR	3.8×10^{-09}	1.7×10^{-08}	1.6×10^{-08}	1.2×10^{-08}	4.5×10^{-08}
Summed ILCR for all Metals	6.0×10^{-08}	2.7×10^{-07}	2.5×10^{-07}	1.9×10^{-07}	7.2×10^{-07}
Age-adjusted Cumulative ILCR	6.0×10^{-08}	3.3×10^{-07}	5.8×10^{-07}	7.8×10^{-07}	1.5×10^{-06}
Project Case					
Arsenic ILCR	1.6×10^{-08}	7.1×10^{-08}	6.6×10^{-08}	5.1×10^{-08}	1.9×10^{-07}
Cadmium ILCR	1.4×10^{-09}	6.4×10^{-09}	5.9×10^{-09}	4.5×10^{-09}	1.7×10^{-08}
Chromium ILCR	4.6×10^{-08}	2.1×10^{-07}	1.9×10^{-07}	1.5×10^{-07}	5.6×10^{-07}
Nickel ILCR	4.8×10^{-09}	2.2×10^{-08}	2.0×10^{-08}	1.5×10^{-08}	5.8×10^{-08}
Summed ILCR for all Metals	7.5×10^{-08}	3.4×10^{-07}	3.2×10^{-07}	2.4×10^{-07}	9.0×10^{-07}
Age-adjusted Cumulative ILCR	7.5×10^{-08}	4.1×10^{-07}	7.3×10^{-07}	9.7×10^{-07}	1.9×10^{-06}
Project-only (Incremental Change)					
Age-adjusted Cumulative ILCR	1.5×10^{-08}	8.3×10^{-08}	1.5×10^{-07}	1.9×10^{-07}	3.8×10^{-07}

Note: *ILCR=incremental lifetime cancer risk*

Of the COPCs, only arsenic is carcinogenic via the ingestion exposure route. The ILCR from arsenic was calculated for each exposure route for Recreational Land Users and was summed to provide an ILCR for the Base Case and Project Case (**Table 5.4-6**). The ILCR for the Project-Only Case (incremental change) was calculated as the Project Case ILCR minus the Base Case ILCR (**Table 5.4-7**). For all human receptors, an ILCR threshold of 1.0×10^{-5} (1 in 100,000) was used to define the acceptable risk for the Project-only Case, as recommended by Health Canada (2019) and BC MOH (2021).

The exposure route that contributes the most to the total ILCR in either the Base Case or Project Case was consumption of market foods. The contribution to the total ILCRs for the Base and Project Case from the other exposure routes was negligible for drinking water, soil ingestion, and soil dermal contact. Subsistence foods ingestion had the next highest contribution to the total ILCR in the Base Case and Project Case but was more than 10 times lower than the contribution from market foods.

The Project-Only ILCRs (incremental change) for Recreational Land Users were below the acceptable risk benchmark of 1.0×10^{-5}, **Table 5.4-7**, and ingestion of arsenic due to the Project is not predicted to cause measurable effects on Human Health for these receptors. A residual effect on Human Health to Recreational Land Users from arsenic ingestion is not predicted.

Table 5.4-6: Incremental Lifetime Cancer Risk from Arsenic Ingestion in Base Case and Project Case for Recreational Land Users

Pathway	Base Case ILCR		Project Case (Operation) ILCR		Project Case (Closure) ILCR	
	Toddler	Adult	Toddler	Adult	Toddler	Adult
Drinking Water (1)	1.6×10^{-06}	4.9×10^{-06}	2.0×10^{-06}	6.1×10^{-06}	3.0×10^{-06}	9.2×10^{-06}
Soil Ingestion (1)	3.9×10^{-06}	5.0×10^{-06}	4.0×10^{-06}	5.2×10^{-06}	4.0×10^{-06}	5.2×10^{-06}
Soil Dermal Contact(1)	1.7×10^{-07}	5.3×10^{-07}	1.8×10^{-07}	5.5×10^{-07}	1.8×10^{-07}	5.5×10^{-07}
Subsistence Foods						
Moose Meat	4.2×10^{-06}	1.3×10^{-05}	4.7×10^{-06}	1.4×10^{-05}	4.4×10^{-06}	1.3×10^{-05}
Moose Liver + Kidney	1.4×10^{-06}	4.5×10^{-06}	1.6×10^{-06}	4.9×10^{-06}	1.5×10^{-06}	4.6×10^{-06}
Deer Meat	4.8×10^{-07}	1.5×10^{-06}	5.3×10^{-07}	1.6×10^{-06}	5.0×10^{-07}	1.5×10^{-06}
Deer Liver + Kidney	1.5×10^{-06}	4.5×10^{-06}	1.6×10^{-06}	5.0×10^{-06}	1.5×10^{-06}	4.6×10^{-06}
Black Bear	7.6×10^{-09}	2.3×10^{-08}	8.8×10^{-09}	2.7×10^{-08}	1.1×10^{-08}	3.3×10^{-08}
Grouse	4.0×10^{-08}	1.2×10^{-07}	4.4×10^{-08}	1.4×10^{-07}	4.1×10^{-08}	1.3×10^{-07}
Snowshoe Hare	5.3×10^{-10}	1.6×10^{-09}	5.8×10^{-10}	1.8×10^{-09}	5.4×10^{-10}	1.7×10^{-09}
Rainbow Trout (1)	4.4×10^{-07}	1.3×10^{-06}	5.1×10^{-07}	1.6×10^{-06}	1.1×10^{-06}	3.5×10^{-06}
Berries (2)	3.3×10^{-07}	8.2×10^{-07}	5.2×10^{-07}	1.3×10^{-06}	3.4×10^{-07}	8.2×10^{-07}
Market Foods	3.4×10^{-04}	8.8×10^{-04}	3.4×10^{-04}	8.8×10^{-04}	3.4×10^{-04}	8.8×10^{-04}
Total ILCR	3.5×10^{-04}	9.2×10^{-04}	3.5×10^{-04}	9.2×10^{-04}	3.5×10^{-04}	9.3×10^{-04}

Source: *Joint FAO/ WHO Expert Committee on Food Additives (JECFA). 2011. Arsenic (addendum). WHO Food Additives Series: 63. FAO JECFA Monographs 8. Prepared by the Seventy-second meeting of the Joint FAO/ WHO Expert Committee on Food Additives (JECFA). Geneva and Rome, 2011.*

Notes: *ILCR=incremental lifetime cancer risk*
[1] *assuming that 100% of soil, water, and fish values are inorganic arsenic*
[2] *assuming that up to 74% of total arsenic is inorganic arsenic (JECFA 2011)*

Table 5.4-7: Incremental Changes between Incremental Lifetime Cancer Risk for the Base Case and Project Cases (Project-only ILCR) for Recreational Land Users

Pathway	Incremental Change (Project-only) ILCR in Operation		Incremental Change (Project-only) ILCR in Closure	
	Toddler	Adult	Toddler	Adult
Drinking Water	1.4×10^{-07}	4.4×10^{-06}	1.4×10^{-06}	4.3×10^{-06}
Soil Ingestion	1.7×10^{-07}	2.2×10^{-07}	1.7×10^{-07}	2.2×10^{-07}
Soil Dermal Contact	7.3×10^{-09}	2.3×10^{-08}	7.3×10^{-09}	2.3×10^{-08}
Subsistence Foods:				
Moose Meat	4.2×10^{-07}	1.3×10^{-06}	1.3×10^{-07}	4.0×10^{-07}
Moose Liver + Kidney	1.4×10^{-07}	4.4×10^{-07}	4.4×10^{-08}	1.3×10^{-07}
Deer Meat	4.9×10^{-08}	1.5×10^{-07}	1.4×10^{-08}	4.4×10^{-08}
Deer Liver + Kidney	1.5×10^{-07}	4.6×10^{-07}	4.3×10^{-08}	1.3×10^{-07}
Black Bear	1.2×10^{-09}	3.7×10^{-09}	3.0×10^{-09}	9.4×10^{-09}
Grouse	4.4×10^{-09}	1.4×10^{-08}	1.0×10^{-09}	3.2×10^{-09}
Snowshoe Hare	5.4×10^{-11}	1.7×10^{-10}	1.4×10^{-11}	4.3×10^{-11}
Rainbow Trout	7.2×10^{-08}	2.2×10^{-07}	7.1×10^{-07}	2.2×10^{-06}
Berries	1.8×10^{-07}	4.5×10^{-07}	1.3×10^{-09}	3.2×10^{-09}
Market Foods	0	0	0	0
Total ILCR	1.3×10^{-06}	3.7×10^{-06}	2.5×10^{-06}	7.4×10^{-06}

Notes: *ILCR=incremental lifetime cancer risk*
Changes in ILCR between Base Case and Project greater than 1.0 x 10^{-5} are bolded and shaded grey.

5.4.3.2 Indigenous and non-Indigenous Resident Land User

5.4.3.2.1 Residual Effects from Non-Carcinogenic Contaminants of Potential Concern (COPCs)

Table 5.4-4 above shows HQ results for Indigenous and non-Indigenous Resident Land Users for the Base Case, Project Case, and the incremental change between Base Case and Project Case in percent for both toddlers and adults. For Resident Land Users, an HQ threshold of 1 was used to define the acceptable risk, since all background exposures were included in the HHRA (Health Canada 2019; BC MOH 2021).

The following five (5) COPCs were above a HQ of 1 for the Resident Land Users toddler in the Base Case: arsenic, cadmium, manganese, molybdenum, and nickel. The same parameters, as well as lithium and thallium, were higher than the HQ threshold of 1 in the Project Case (Closure). Three (3) parameters (arsenic, manganese, and nickel) were above the HQ threshold of 1 for the Resident Land User adult in the Base Case, and four (4) (arsenic, manganese, nickel, and thallium) in the Project Case (Closure).

Arsenic had the highest calculated HQ of 11 (toddler) and 3.6 (adult) in both the Base Case and Project Case, where essentially all of the total risk came from ingestion of market foods.

For inhalation, ingestion of drinking water, ingestion of subsistence foods, incidental ingestion of soil, and dermal contact with soil, HQs for the individual exposure routes were negligible (generally, 2 to 10,000 times lower than the market foods exposure pathway, except for thallium in Closure) and no COPCs had

HQs higher than 1 in any of these individual exposure routes in either the Base Case or Project Case (Attachment G of **Appendix 8.0-A**).

The HQs for the majority of COPCs did not change significantly (less than 20% incremental change; **Table 5.4-4**) between Base Case and Project Case, except for cobalt, lithium, and strontium (all approximately 2 to 40% increase), and boron and thallium (approximately 100 to 175% increase; all increases quoted for Project Case [Closure]). As stated in **5.4.3.1** for Recreational Land Users, an incremental change in HQ of less than 20% can be considered **Not Significant** as it is within the range of variability and margin of error of measurable COPCs concentrations in air, water, soil, and foods and is unlikely to be detectable in environmental monitoring programs. In addition, given the conservative assumptions used in the risk assessment (e.g., all subsistence foods eaten by a person in a year come from within the LSA, small TRVs due to safety factors of up to 1,000 fold), environmental media variability, and the inherent uncertainties in risk assessment, for the COPCs where the HQ was greater than 1 but the Project-related incremental change in HQ was less than 20%, measurable changes in Human Health due to the Project are unlikely.

Although the incremental increase in HQs for boron, cobalt, and strontium are greater than 20% in the Project Case (Closure) scenario for Resident Land Users, the HQs remain below the threshold of 1 (**Table 5.4-4**). Thus, it is concluded that exposure to boron, cobalt, and strontium do not pose a health risk to Resident Land Users. The incremental increase is a result of small, predicted increases in concentrations of boron in surface water and soil, and a predicted increase in strontium in drinking water.

The increases in total HQ for lithium in the Project Case (Closure) scenario is due to an increase in HQs in subsistence foods, especially rainbow trout, due to a predicted increase in lithium concentrations in surface water in the Decommissioning and Reclamation Phase. Drinking water HQs for lithium remain below the threshold HQ of 1, and the total HQ for lithium for toddlers (1.1) in Project Case (Closure) is only marginally greater than one (1), and does not exceed one (1) for adults. The background HQ from ingestion of market foods is higher compared to risks from eating subsistence foods. It is unlikely that the predicted increase in risk will result in measurable effects on Resident Land User toddlers. Nevertheless, lithium should be included in follow-up programs to confirm that future measured concentrations remain within the range predicted in surface waters and fish tissues.

The incremental increase in total HQ for thallium in the Project Case (Operation and Closure) scenarios is due to the contribution of thallium from surface water and subsistence foods, especially rainbow trout (Table 4.3-10 to Table 4.3-12 in **Appendix 8.0-A**). The total HQs for thallium are marginally greater than the threshold of one (1) in Project Case (Closure); 1.0 and 1.6 for toddler and adult, respectively, but not in Project Case (Operation). Thallium concentration may increase in fish because thallium concentrations are predicted to increase in surface water downstream of the Project. However, drinking water HQs remain below threshold HQs of 1 in Project Case and, therefore, drinking water from creeks and streams in the LSA is not predicted to result in health risks to Resident Land Users.

The level of incremental change in HQs due to ingestion of thallium is not likely to result in measurable effects on Resident Land Users. This conclusion is based on the same considerations already described in **5.4.3.1** for the Recreational Land User and are not repeated here. However, due to the uncertainties in the risk assessment for thallium, it should be included in future follow-up programs to confirm that future measured concentrations remain within the range predicted in surface waters and in fish tissues.

Based on the HHRA and the analysis of potential risks from exposure to non-carcinogenic COPCs for Indigenous and non-Indigenous Resident Land Users presented in the preceding paragraphs (with additional detail provided in **Appendix 8.0-A**), a residual effect on Human Health is predicted (i.e., the Project-related incremental change is not zero).

5.4.3.2.2 Residual Effects from Carcinogenic Contaminants of Potential Concern (COPCs)

Arsenic, cadmium, chromium, and nickel are the COPCs considered to be carcinogens via the inhalation route. Inhalation ILCRs for arsenic, cadmium, chromium, and nickel were calculated for each life stage and then summed since all four (4) parameters have the potential to cause lung cancer (i.e., same endpoint). The ILCR for the Project-only Case (incremental change) was calculated as the Project Case ILCR minus the Base Case ILCR (**Table 5.4-8**). For all human receptors, an ILCR threshold of 1 x 10^{-5} (1 in 100,000) was used to define the acceptable risk for the Project-Only Case, as recommended by Health Canada (2019) and BC MOH (2021).

As shown in **Table 5.4-8**, the calculated Project-only ILCR for Indigenous and non-Indigenous Resident Land User adults for carcinogens via the inhalation exposure route is below the acceptable threshold of 1.0 x 10^{-5}. The Project-only ILCR is within acceptable limits and no residual effects on Recreational Land Users are expected from carcinogenic COPCs via the inhalation exposure route.

Table 5.4-8: Incremental Lifetime Cancer Risk via Inhalation for Carcinogenic Contaminants of Potential Concern (COPCs) for Indigenous and Non-Indigenous Resident Land Users

	Infant	Toddler	Child	Teen	Adult
Base Case					
Arsenic ILCR	8.8 x 10^{-08}	3.9 x 10^{-07}	3.7 x 10^{-07}	2.8 x 10^{-07}	1.1 x 10^{-06}
Cadmium ILCR	7.9 x 10^{-09}	3.6 x 10^{-08}	3.3 x 10^{-08}	2.5 x 10^{-08}	9.5 x 10^{-08}
Chromium ILCR	2.3 x 10^{-07}	1.0 x 10^{-06}	9.5 x 10^{-07}	7.2 x 10^{-07}	2.7 x 10^{-06}
Nickel ILCR	2.5 x 10^{-08}	1.1 x 10^{-07}	1.0 x 10^{-07}	7.9 x 10^{-08}	2.9 x 10^{-07}
Summed ILCR for all Metals	3.9 x 10^{-07}	1.8 x 10^{-06}	1.6 x 10^{-06}	1.3 x 10^{-06}	4.7 x 10^{-06}
Age-adjusted Cumulative ILCR	3.9 x 10^{-07}	2.2 x 10^{-06}	3.8 x 10^{-06}	5.1 x 10^{-06}	9.8 x 10^{-06}
Project Case					
Arsenic ILCR	1.0 x 10^{-07}	4.6 x 10^{-07}	4.3 x 10^{-07}	3.3 x 10^{-07}	1.2 x 10^{-06}
Cadmium ILCR	9.2 x 10^{-09}	4.1 x 10^{-08}	3.9 x 10^{-08}	2.9 x 10^{-08}	1.1 x 10^{-07}
Chromium ILCR	3.0 x 10^{-07}	1.4 x 10^{-06}	1.3 x 10^{-06}	9.6 x 10^{-07}	3.6 x 10^{-06}
Nickel ILCR	3.1 x 10^{-08}	1.4 x 10^{-07}	1.3 x 10^{-07}	1.0 x 10^{-07}	3.8 x 10^{-07}
Summed ILCR for all Metals	4.9 x 10^{-07}	2.2 x 10^{-06}	2.1 x 10^{-06}	1.6 x 10^{-06}	5.9 x 10^{-06}
Age-adjusted Cumulative ILCR	4.9 x 10^{-07}	2.7 x 10^{-06}	4.8 x 10^{-06}	6.3 x 10^{-06}	1.2 x 10^{-05}
Project-Only (Incremental Change)					
Age-adjusted Cumulative ILCR	9.8 x 10^{-08}	5.4 x 10^{-07}	9.5 x 10^{-07}	1.3 x 10^{-06}	2.4 x 10^{-06}

Note: *ILCR=incremental lifetime cancer risk*

Of the COPCs, only arsenic is carcinogenic via the ingestion exposure route. The ILCR from arsenic was calculated for each exposure route for Indigenous and non-Indigenous Resident Land Users and was summed to provide an ILCR for the Base Case and Project Case (**Table 5.4-9).** The ILCR for the Project-only Case (incremental change) was calculated as the Project Case ILCR minus the Base Case ILCR (**Table 5.4-10**). For all human receptors, an ILCR threshold of 1.0×10^{-5} (1 in 100,000) was used to define the acceptable risk for the Project-Only Case, as recommended by Health Canada (2019) and BC MOH (2021).

The exposure route that contributes the most to the total ILCR in either the Base Case or Project Case was consumption of market foods. The contribution to the total ILCRs for the Base and Project Case from the other exposure routes was negligible for soil dermal contact; however, drinking water and soil ingestion contributed slightly greater than 10^{-5} in Base and Project Case, but was more than 10 times less than the contribution from market foods. Subsistence foods ingestion had the next highest contribution to the total ILCR in the Base Case and Project Case but was also more than 10 times lower than the contribution from market foods.

The Project-only ILCRs (incremental change) for Resident Land Users were below the acceptable risk benchmark of 1.0×10^{-5}, except for the total ILCR for adults in Project Case (Closure, in **Table 5.4-10**; 1.9×10^{-5}), with the largest contribution from drinking water (1.4×10^{-5}). The second largest contributions to the incremental change was from consumption of rainbow trout, due to an increase in predicted surface water arsenic concentrations during the Decommissioning and Reclamation Phase. All other exposure pathways that may be influenced by the Project (ingestion and dermal contact with soil, ingestion of subsistence foods) contribute negligible amounts to the change in the total Project-only ILCR from exposure to arsenic.

This small, incremental change in ILCR from ingestion of arsenic due to the Project is not predicted to cause measurable effects on human health for the adult Resident Land User receptors. However, as there is an incremental increase in the total ILCR above the threshold of 1.0×10^{-5}, a residual effect on human health of Indigenous and non-Indigenous Resident Land Users is predicted.

Table 5.4-9: Incremental Lifetime Cancer Risk from Arsenic Ingestion in Base Case and Project Case for Indigenous and Non-Indigenous Resident Land Users

Pathway	Base Case ILCR		Project Case (Operation) ILCR		Project Case (Closure) ILCR	
	Toddler	Adult	Toddler	Adult	Toddler	Adult
Drinking Water (1)	1.5×10^{-05}	4.6×10^{-05}	1.5×10^{-05}	4.6×10^{-05}	2.0×10^{-05}	6.0×10^{-05}
Soil Ingestion (1)	2.5×10^{-05}	3.3×10^{-05}	2.6×10^{-05}	3.4×10^{-05}	2.6×10^{-05}	3.4×10^{-05}
Soil Dermal Contact (1)	1.1×10^{-06}	3.4×10^{-06}	1.1×10^{-06}	3.6×10^{-06}	1.1×10^{-06}	3.6×10^{-06}
Subsistence Foods:						
Moose Meat	4.2×10^{-06}	1.3×10^{-05}	4.7×10^{-06}	1.4×10^{-05}	4.4×10^{-06}	1.3×10^{-05}
Moose Liver + Kidney	1.4×10^{-06}	4.5×10^{-06}	1.6×10^{-06}	4.9×10^{-06}	1.5×10^{-06}	4.6×10^{-06}
Deer Meat	4.8×10^{-07}	1.5×10^{-06}	5.3×10^{-07}	1.6×10^{-06}	5.0×10^{-07}	1.5×10^{-06}
Deer Liver + Kidney	1.5×10^{-06}	4.5×10^{-06}	1.6×10^{-06}	5.0×10^{-06}	1.5×10^{-06}	4.6×10^{-06}
Black Bear	7.6×10^{-09}	2.3×10^{-08}	8.8×10^{-09}	2.7×10^{-08}	1.1×10^{-08}	3.3×10^{-08}
Grouse	4.0×10^{-08}	1.2×10^{-07}	4.4×10^{-08}	1.4×10^{-07}	4.1×10^{-08}	1.3×10^{-07}
Snowshoe Hare	5.3×10^{-10}	1.6×10^{-09}	5.8×10^{-10}	1.8×10^{-09}	5.4×10^{-10}	1.7×10^{-09}
Rainbow Trout (1)	4.4×10^{-07}	1.3×10^{-06}	5.1×10^{-07}	1.6×10^{-06}	1.1×10^{-06}	3.5×10^{-06}
Berries (2)	3.3×10^{-07}	8.2×10^{-07}	5.2×10^{-07}	1.3×10^{-06}	3.4×10^{-07}	8.2×10^{-07}
Garden Produce (2)	1.2×10^{-06}	3.0×10^{-06}	1.4×10^{-06}	3.4×10^{-06}	1.2×10^{-06}	3.0×10^{-06}
Market Foods	3.4×10^{-04}	8.8×10^{-04}	3.4×10^{-04}	8.8×10^{-04}	3.4×10^{-04}	8.8×10^{-04}
Total ILCR	3.9×10^{-04}	9.9×10^{-04}	3.9×10^{-04}	1.0×10^{-03}	4.0×10^{-04}	1.0×10^{-03}

Source: *Joint FAO/ WHO Expert Committee on Food Additives (JECFA). 2011. Arsenic (addendum). WHO Food Additives Series: 63. FAO JECFA Monographs 8. Prepared by the Seventy-second meeting of the Joint FAO/ WHO Expert Committee on Food Additives (JECFA). Geneva and Rome, 2011.*

Notes: *ILCR = incremental lifetime cancer risk*

[1] assuming that 100% of soil, water, and fish values are inorganic arsenic

[2] assuming that up to 74% of total arsenic is inorganic arsenic (JECFA 2011)

Table 5.4-10: Incremental Changes between Incremental Lifetime Cancer Risk (ILCR) for the Base Case and Project Cases (Project-only ILCR) for Indigenous and Non-Indigenous Resident Land Users

Pathway	Incremental Change (Project-Only) ILCR in Operation		Incremental Change (Project-Only) ILCR in Closure	
	Toddler	Adult	Toddler	Adult
Drinking Water	1.4×10^{-07}	4.4×10^{-07}	4.7×10^{-06}	**1.4×10^{-05}**
Soil Ingestion	1.1×10^{-06}	1.4×10^{-06}	1.1×10^{-06}	1.4×10^{-06}
Soil Dermal Contact	4.8×10^{-08}	1.5×10^{-07}	4.8×10^{-08}	1.5×10^{-07}
Subsistence Foods:				
Moose Meat	4.2×10^{-07}	1.3×10^{-06}	1.3×10^{-07}	4.0×10^{-07}
Moose Liver + Kidney	1.4×10^{-07}	4.4×10^{-07}	4.4×10^{-08}	1.3×10^{-07}
Deer Meat	4.9×10^{-08}	1.5×10^{-07}	1.4×10^{-08}	4.4×10^{-08}
Deer Liver + Kidney	1.5×10^{-07}	4.6×10^{-07}	4.3×10^{-08}	1.3×10^{-07}
Black Bear	1.2×10^{-09}	3.7×10^{-09}	3.0×10^{-09}	9.4×10^{-09}
Grouse	4.4×10^{-09}	1.4×10^{-08}	1.0×10^{-09}	3.2×10^{-09}
Snowshoe Hare	5.4×10^{-11}	1.7×10^{-10}	1.4×10^{-11}	4.3×10^{-11}
Rainbow Trout	7.2×10^{-08}	2.2×10^{-07}	7.1×10^{-07}	2.2×10^{-06}
Berries	1.8×10^{-07}	4.5×10^{-07}	1.3×10^{-09}	3.2×10^{-09}
Garden Produce	1.6×10^{-07}	4.0×10^{-07}	4.7×10^{-09}	1.2×10^{-08}
Market Foods	0	0	0	0
Total ILCR	2.5×10^{-06}	5.5×10^{-06}	6.8×10^{-06}	**1.9×10^{-05}**

Notes: *ILCR = incremental lifetime cancer risk*
Changes in ILCR between Base Case and Project greater than 1.0×10^{-5} are bolded and shaded grey

5.4.3.3 Residual Effect Characteristics

Characterisation of residual effects on Human Health from changes in concentrations of metal COPCs in environmental media includes an assessment of Magnitude, Geographic Extent, Duration, Frequency, Reversibility, and Context, based on the definitions for each criterion provided in **Table 5.4-1** of this chapter and **5.4.1** of **S3.0 Assessment Methodology** This characterisation is based primarily on the COPCs with the highest incremental change between the Base Case and Project Case and the greatest potential for causing a change in human health (i.e., thallium for non-carcinogenic COPCs and arsenic for carcinogenic COPCs); this approach will result in the most conservative residual effects characterisation. The ratings for residual effects on Human Health from exposure to metal COPCs are summarized in **Table 5.4-11,** with the rationale for the ratings provided in the third column of the table.

Table 5.4-11: Summary of Effect Characteristics Ratings for Human Health due to Changes in Environmental Media Quality

Residual Effects Characteristic	Rating	Rationale for Rating
Non-carcinogenic Contaminants of Potential Concern (All Pathways)		
Magnitude	Moderate	The changes in Human Health, as estimated by HQs in the Project Case, are predicted to increase up to 175% (thallium) relative to the Base Case. The largest contribution to the Base Case and Project Case HQs is generally from COPCs in market foods, which is independent of the Project. The HQ for thallium is within the range of uncertainty for effects on Human Health.
Geographic Extent	Local	Increases in thallium concentrations in water and fish tissue were predicted for Goathorn Creek, Four Creek, Tenas Creek, and Telkwa River (at the confluence with Tenas Creek) close to the Minesite but are not predicted to extend to the Bulkley River. Residual effects due to thallium in surface water are therefore local (limited to the LSA).
Duration	Long-term	Effects are predicted to persist throughout the Project phases.
Frequency	Infrequent	Residual effects from ingestion of subsistence foods (fish) are only predicted to occur, based on calculated HQs, if local non-anadromous fish are consumed. No effects are expected from consumption of anadromous species, such as salmon, which are consumed most often.
Reversibility	Fully reversible	Residual effects on Human Health are likely to be fully reversible. Human Health is expected to revert to Base Case conditions.
Context	Low	People can have varying degrees of sensitivity and ability to adapt to stressors (resiliency), depending on multiple of other non-biophysical factors (such as individual-specific socio-economic, genetic, health (physical, spiritual, or cultural) factors) that also influence overall Human Health. Resiliency is expected to be high.
Carcinogenic Contaminants of Potential Concern (Ingestion)		
Magnitude	Low	The range of change in Human Health, as estimated by ILCRs in the Project-only Case, is predicted to be within two (2) times of the acceptable threshold value of 10^{-5}. Market foods contribute 10 times more to the total ILCRs than Project-related contributions.
Geographic Extent	Local	Effects are limited to the LSA because increases in arsenic in fish tissue and drinking water have been predicted to occur close to the Minesite but are not predicted to extend to the Bulkley River.

Residual Effects Characteristic	Rating	Rationale for Rating
Duration	Long-term	Effects from exposure to carcinogenic COPCs have the potential to last a lifetime.
Frequency	Infrequent	Contributions of arsenic to drinking water in surface water discharges are anticipated to occur only during winter months. Residual effects from ingestion of subsistence foods (fish) are only predicted to occur, based on calculated ILCRs, if local non-anadromous fish are consumed. No effects are expected from consumption of anadromous species, such as salmon, which are consumed most often.
Reversibility	Partially Reversible	Effects from exposure to carcinogenic COPCs are partially reversible.
Context	Low	People have varying degrees of sensitivity and ability to adapt to stressors (resiliency), depending on multiple other non-biophysical factors (such as individual-specific socio-economic, genetic, physical, spiritual, or cultural factors) that also influence overall Human Health. Resiliency is expected to be high.

Notes: *%=percent; COPCs=Contaminants of Potential Concern; ILCR=incremental lifetime cancer risk; LSA=Local Study Area*

5.4.3.4 Likelihood

Residual effects on Human Health due to changes in concentrations of COPCs in environmental media are considered **Unlikely** since the Project-related incremental changes in HQs and ILCRs are low, with higher contributions from market foods compared to contributions from the Project. Measurable changes to Human Health are unlikely to occur.

5.4.3.5 Significance Determination

The residual effect of change in Human Health from change in environmental media COPC concentrations as a result of the Project is not expected to alter its integrity within the Human Health LSA to an unacceptable level. The effect from non-carcinogenic COPCs is predicted to be of Moderate Magnitude, Local Extent, Long-term Duration, and Fully Reversible. The effect from carcinogenic COPCs is predicted to be of Low Magnitude, Local Extent, Long-term Duration, and Partially Reversible. Therefore, the effect of change in Human Health is predicted to be **Not Significant.**

The Level of Confidence is Moderate as a quantitative assessment was completed using regulator provided TRV thresholds of which some (e.g., thallium) have higher levels of uncertainty. Standard HHRA models and Project-specific and receptor-specific information were used where possible. Conservative assumptions have been made to increase confidence in the HHRA modelling.

5.4.4 Residual Effects on Human Health due to Noise

Potential changes in daytime and nighttime noise levels in the LSA and RSA were modelled using the CadnaA noise propagation modelling software. Modelling and results are described in **S4.0-C1** and **Appendix 4.1-A**. Modelling results for receptor locations are also presented in **Table 5.4-12**. Receptor locations included private residences, a cabin, schools, childcare facilities, and the TCRC.

Isopleth figures describing predicted ambient noise levels distributed over a receptor grid with a uniform spacing of 50 m within the noise RSA are shown in **Appendix 4.1-A** of **S4.0-C1**. The highest noise levels are expected to occur in the immediate vicinity of equipment and activity at the open pit.

For comparison with permissible sound levels (PSLs) from the BC Noise Control Best Practices Guideline (BC Oil and Gas Commission [BC OGC] 2018), the Health Canada %HA threshold level (Health Canada 2017b), and the WHO night noise guidelines (WHO 2009), Base Case noise levels were assigned to each sensitive receptor location based on the Base Case noise measurements from 1998 and 2017 to 2018 (see **S4.0-C1-4.2.4 Noise**) and added to the estimated Project noise levels from Operation Phase noise modelling.

Table 5.4-12: Predicted Noise Levels at Human Health Receptor Locations

Receptor Type	UTM Easting	UTM Northing	Community Type (1)	Base Case		Project-Only		Project + Base Case		PSL (2)		Change in %HA
				Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	
TCRC	620359	6055109	quiet rural	35.7	23.1	47.2	30.5	47.5	31.2	50	40	1
Residence	621045	6057791	quiet suburban residential	45.6	**42.1**	11	11	45.6	**42.1**	58	48	0
Residence	621147	6057863	quiet suburban residential	45.6	**42.1**	10.3	10.3	45.6	**42.1**	58	48	0
Residence	621148	6057784	quiet suburban residential	45.6	**42.1**	11.4	11.4	45.6	**42.1**	58	48	0
Residence	621151	6058015	quiet suburban residential	45.6	**42.1**	7.2	7.2	45.6	**42.1**	58	48	0
Residence	621219	6057843	quiet suburban residential	45.6	**42.1**	10.8	10.8	45.6	**42.1**	58	48	0
Residence	621236	6058089	quiet suburban residential	45.6	**42.1**	4.2	4.2	45.6	**42.1**	58	48	0
Residence	621246	6057883	quiet suburban residential	45.6	**42.1**	10.3	10.3	45.6	**42.1**	58	48	0
Residence	621248	6058191	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	58	48	0
Residence	621260	6058012	quiet suburban residential	45.6	**42.1**	7.8	7.8	45.6	**42.1**	58	48	0
Residence	621311	6058287	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	58	48	0
Residence	621330	6058317	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	58	48	0
Residence	621347	6057296	quiet rural	35.7	23.1	17.4	17.4	35.8	24.1	55	45	0
Residence	621359	6055187	quiet rural	35.7	23.1	42.1	24.1	43	26.6	50	40	0.4
Residence	624301	6058433	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624310	6058125	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0

Receptor Type	UTM Easting	UTM Northing	Community Type [1]	Base Case		Project-Only		Project + Base Case		PSL [2]		Change in %HA
				Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	
Residence	624317	6058312	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624413	6058467	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624495	6057858	quiet suburban residential	45.6	***42.1***	30.5	2.2	45.7	***42.1***	50	40	0
Residence	624511	6059467	quiet rural	35.7	23.1	0	0	35.7	23.1	50	40	0
Residence	624516	6058298	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624533	6058522	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624542	6058470	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624551	6060520	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	58	48	0
Residence	624618	6058496	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624633	6060666	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	58	48	0
Residence	624652	6058012	quiet suburban residential	45.6	**42.1**	12.5	0	45.6	**42.1**	53	43	0
Residence	624666	6058350	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624707	6060548	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	58	48	0
Residence	624709	6058331	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624728	6060340	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624738	6058471	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0

Receptor Type	UTM Easting	UTM Northing	Community Type [1]	Base Case		Project-Only		Project + Base Case		PSL [2]		Change in %HA
				Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	
Residence	624750	6060645	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	58	48	0
Residence	624755	6058337	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624811	6060513	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624833	6058269	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624835	6060701	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	58	48	0
Residence	624848	6058478	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624887	6057904	quiet suburban residential	45.6	***42.1***	28.9	0	45.7	***42.1***	50	40	0
Tot Spot Family Day Care	624899	6061799	noisy urban residential	***61.4***	***59***	0	0	***61.4***	***59***	58	48	0
Residence	624917	6058542	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624946	6058333	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624949	6060663	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	624985	6060414	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625012	6058547	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625027	6060650	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625055	6058312	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0

Receptor Type	UTM Easting	UTM Northing	Community Type (1)	Base Case		Project-Only		Project + Base Case		PSL (2)		Change in %HA
				Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	
Residence	625110	6060346	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625125	6058347	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625140	6058498	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625166	6060570	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625211	6060248	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625238	6060113	quiet suburban residential	45.6	***42.1***	0	0	45.6	***42.1***	50	40	0
Residence	625293	6060420	quiet suburban residential	45.6	**42.1**	0	0	45.6	**42.1**	53	43	0
Residence	625493	6060254	quiet suburban residential	45.6	***42.1***	0	0	45.6	***42.1***	50	40	0
Residence	625561	6060138	quiet suburban residential	45.6	***42.1***	0	0	45.6	***42.1***	50	40	0
Telkwa Elementary	625731	6062745	noisy urban residential	***61.4***	***59***	0	0	***61.4***	***59***	58	48	0
The Ark Playday Center	625732	6062821	noisy urban residential	***61.4***	***59***	0	0	***61.4***	***59***	58	48	0
Residence	625808	6060035	quiet suburban residential	45.6	***42.1***	0	0	45.6	***42.1***	50	40	0
Cabin	626743	6062021	quiet rural	35.7	23.1	0	0	35.7	23.1	55	45	0
Residence	628318	6058826	quiet rural	41.3	38	29.9	29.9	41.6	38.6	55	45	0.1
Residence	628469	6058607	quiet rural	41.3	38	32.2	32.2	41.8	39	50	40	0.1
Residence	628475	6058809	quiet rural	41.3	38	31.4	31.4	41.7	38.9	55	45	0.1
Residence	628542	6058933	quiet rural	41.3	38	31.4	31.4	41.7	38.9	55	45	0.1

Receptor Type	UTM Easting	UTM Northing	Community Type (1)	Base Case		Project-Only		Project + Base Case		PSL (2)		Change in %HA
				Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	Ld (dBA)	Ln (dBA)	
Residence	629162	6059498	quiet rural	41.3	38	31.1	31.1	41.7	38.8	55	45	0.1
Residence	629311	6059475	quiet rural	41.3	38	31.9	31.9	41.8	39	55	45	0.1
Residence	629376	6059417	quiet rural	41.3	38	32.8	32.8	41.9	39.2	55	45	0.2
Residence	629378	6058797	quiet rural	41.3	38	41.8	**41.8**	44.6	**43.3**	55	45	1
Residence	629404	6059357	quiet rural	41.3	38	33.6	33.6	42	39.4	55	45	0.2
Residence	629422	6059314	quiet rural	41.3	38	34.2	34.2	42.1	39.5	55	45	0.2
Residence	630293	6058896	quiet rural	41.3	38	36.6	36.6	42.6	**40.4**	55	45	0.4
Residence	630457	6057731	quiet rural	41.3	38	36.9	36.9	42.7	**40.5**	55	45	0.4
Residence	630474	6057528	quiet rural	41.3	38	35.1	35.1	42.3	39.8	55	45	0.3
Residence	630568	6058612	quiet rural	41.3	38	35.7	35.7	42.4	**40**	55	45	0.3
Residence	630843	6058516	quiet rural	41.3	38	32.8	32.8	41.9	39.2	55	45	0.2
Residence	630879	6058459	quiet rural	41.3	38	32.5	32.5	41.9	39.1	55	45	0.2
Residence	630907	6057496	quiet rural	41.3	38	30.7	30.7	41.7	38.7	55	45	0.1
Residence	630914	6058404	quiet rural	41.3	38	32.3	32.3	41.8	39	55	45	0.1
Residence	630925	6057608	quiet rural	41.3	38	31	31	41.7	38.8	55	45	0.1
Residence	630943	6058355	quiet rural	41.3	38	32	32	41.8	39	55	45	0.1
Residence	631013	6057550	quiet rural	41.3	38	29.9	29.9	41.6	38.6	55	45	0.1

Sources: *World Health Organization (WHO) 2009, Health Canada 2017b*
Notes: *dBA=A-weighted decibels; Ld=daytime noise levels; Ln=nighttime noise levels; PSL=Permissible sound levels; UTM=Universal Traverse Mercator; WHO=World Health Organization; %HA=percent highly annoyed; TCRC=Telkwa Coalmine Recreation Camp*
(1) Based on estimated Baseline Ldn sound levels and Health Canada (2017b).
(2) British Columbia Oil and Gas Commission (BC OGC). 2018. British Columbia Noise Control Best Practices Guideline. Version 2.1.
Bold and grey highlight = Values for Ln are higher than WHO (2009) outdoor threshold value of 40 dBA for assessment of sleep disturbance, or %HA is higher than Health Canada (2017b) threshold value of 6.5%.
Bold italics and grey highlight = Ld and Ln values are higher than BC OGC PSLs.

The %HA in a population was calculated for the baseline day-night sound level and for the combined (i.e., Project + Base Case) day-night sound level. The difference between the two (2) was then compared to Health Canada's threshold of 6.5%HA. Modelling results are presented in **Table 5.4-12**.

Maximum Ld and Ln are expected to remain below the PSLs at all rural residences and at the TCRC. Ln may exceed the nighttime WHO threshold for sleep disturbance of 40 dBA (see **5.4.4.1**) at several rural residences within the nearby residential subdivisions or the Rail Infrastructure; however, these exceedances are related to background noise levels for most cases rather than the Project, except for the residences located near the future Rail Infrastructure, where the Project may contribute to an increase in Ln.

Despite predicted increases in noise levels at some locations, the change in %HA (see **5.4.4.3**) is expected to remain below the Health Canada threshold of 6.5% at all sensitive receptor locations in the LSA and RSA. The maximum expected change in % HA of 1 is at the TCRC and at one (1) residence; however, in both cases Project + Base Case sound levels remain below the applicable PSLs for day- and nighttime.

5.4.4.1 Sleep Disturbance

The WHO has published night-time noise guidelines that are intended to protect the public from adverse health effects associated with sleep disturbance due to night-time noise. The recommended annual average at or below which there should be no long-term effect on health is 40 dBA Ln outdoors (WHO 2009). As this is an annual average, there may be times when the sound level can be above or below 40 dBA.

This approach is also adopted by Health Canada (Health Canada 2017b) and the 40 dBA level is also considered the basic nighttime permissible sound level (PSL) by the (BC OGC 2018). This basic nighttime PSL is commonly adjusted to account for existing population density and for proximity to existing transportation (BC OGC 2018). With adjustments, the PSL ranges from 40 to 48 dBA.

The WHO Ln threshold of 40 dBA is exceeded already under baseline conditions at many locations including the Telkwa Elementary, the Ark Playday Centre, the Tot Spot Family Day Care and at several residences, without any additional noise contributed by the Project (**Table 5.4-12)**. It is not expected that facilities such as the Telkwa Elementary, the Ark Playday Centre, and the Tot Spot Family Day Care are used at night-time. For these facilities, and for many of the residences, no incremental change in noise levels due to the Project are predicted.

Residences located near the Rail Infrastructure are predicted to have an increase in the calculated Ln. While noise levels are predicted to remain below the adjusted PSL, some residences near the Rail Infrastructure may occasionally experience Ln in excess of 40 dBA (WHO threshold) during Project Operation, which are currently (baseline conditions) characterized as "quiet rural" and have night-time sound levels of less than 40 dBA. Therefore, an increase in sleep disturbance may occur at these residences due to the operation of the Project.

To minimize the potential for sleep disturbance, while direct loading of the trains from the stockpile will be carried out seven (7) days a week, loading will be done during dayshift hours between 0600 and 1700 hours as much as possible (Telkwa Coal Ltd. 2018). Noise mitigation and monitoring, including a Trigger Action Response Plan (TARP), will be developed and implemented as described in the **AQMP**. Noise is expected to be lower during Decommissioning and Reclamation, and Post-closure phases.

5.4.4.2 Interference with Communication

To sustain good outdoor speech comprehension (where people typically speak louder), background outdoor noise levels for continuous noise should be kept below 55 dBA (Health Canada 2017b). As shown in **Table 5.4-12**, this recommended outdoor sound level is exceeded already under baseline conditions at the Telkwa Elementary, the Ark Playday Centre, and the Tot Spot Family Day Care. The Project is not expected to contribute any additional noise at these three (3) receptor locations.

Rural residences located near the Rail Infrastructure and Rail Loadout and the TCRC are predicted to experience Project-related increases in Ld, but levels are expected to remain below the 55 dBA human health threshold. Therefore, Project-related interference with communication due to Project activities during Operation is expected to be negligible. Noise is expected to be lower during Decommissioning and Reclamation, and Post-closure phases.

5.4.4.3 Complaints and High Level of Annoyance

Health Canada recommends calculation of an expected change in the percentage of %HA people in an average community (Health Canada 2017b) to be used as one of the indicators of potential human health effects.

There may be a small (up to 1%) change in the percentage of people at the TCRC or at residences located near the Rail Infrastructure who may be annoyed by Project Operation Phase noise, over and above baseline noise levels, and may raise complaints. The perception of what is an annoying sound is highly individual and in part depends on a person's expectation. People who spend time at the TCRC or live at a rural residence may have an expectation that ambient sounds are restricted to natural sounds and occasional traffic but may experience an increase in sound levels from Project-activity related noise such as an increase in traffic and rail noise. Based on modelling, the maximum expected change in %HA does not exceed 1 at the TCRC or at residences during Operation (Table 3-1 of **Appendix 4.1-B)**. It is highly unlikely that this estimated maximum 1% change in HA will lead to complaints as it is substantially below the threshold of 6.5 %, which is the accepted threshold for potential human health effects based on complaints (Michaud, Bly, and Keith 2008; Health Canada 2017b). Noise is expected to be lower during Decommissioning and Reclamation, and Post-closure phases.

5.4.4.4 Residual Effect Characteristics

The effects characteristics ratings for residual effects on Human Health due to noise are listed in **Table 5.4-13**. The Project will result in noise emissions and an increase in ambient noise levels. The Magnitude of the residual effect on Human Health is rated Moderate as Project contribution to ambient noise levels are measurable, above baseline levels at the TCRC and the residences closest to the Project but are expected to remain below human health thresholds (%HA). The change in ambient noise levels will be limited to the LSA (i.e., Local Geographic Extent, based on noise modelling results), which is currently moderately disturbed by existing agricultural and logging activity (i.e., Moderate Context). Project-related noise emissions are Continuous (24 hours) and are expected to last for the life of the Project but are expected to be lower during the Decommissioning and Reclamation Phase, and lower again during the Post-closure phase, upon which effects will be Fully Reversible as Project activities diminish.

Table 5.4-13: Summary of Effect Characteristics Ratings for Human Health due to Changes in Noise Levels

Residual Effects Characteristic	Rating	Rationale for Rating
Magnitude	Moderate	Project-related noise levels exceeds the Base Case at nearby residences and the TCRC but are expected to remain below PSLs and health-based thresholds for sleep disturbance and %HA. Some residences located near the Rail Infrastructure may experience an increase in nighttime noise levels (Ln) from below to above the recommended WHO level for sleep disturbance (but remaining below the PSLs), but not an increase in %HA above 1%.
Geographic Extent	Local	Effects are limited to parts of the LSA.
Duration	Medium-term	Effects are expected to last for the duration of the Project and cease upon commencement of the Post-closure Phase.
Frequency	Continuous	Mining activities contributing to noise emissions are continuous or near continuous. However, blasting is restricted to daytime only and noise is predicted to be less during nighttime than during daytime.
Reversibility	Fully Reversible	Change in noise levels are Fully Reversible after the Post-closure Phase.
Context	Moderate	People have varying degrees of sensitivity and ability to adapt to stressors (resiliency), depending on a multiple of other non-biophysical factors (such as individual-specific socio-economic, genetic, physical, spiritual, or cultural factors) that also influence overall Human Health. Perception or, and annoyance by, noise is highly individual-dependent, but is overall rated as Moderate because the LSA is already disturbed by existing activities.

Notes: *%HA=percent highly annoyed; LSA=Local Study Area; PSL=permissible sound level; TCRC=Telkwa Coalmine Recreation Camp; WHO=World Health Organization*

5.4.4.5 Likelihood

Residual effects on Human Health due to an increase in noise levels are considered Likely, as the assessment was based on quantitative noise modelling that considered Project-specific (e.g., Project-related noise sources and timing of noise generation) and LSA-specific (e.g., receptor locations, types of receptors) information.

5.4.4.6 Significance Determination

The residual effect of change in Human Health from change in noise levels as a result of the Project is not expected to alter its integrity within the Human Health LSA to an unacceptable level. The effect from the change in noise levels is predicted to be of Moderate Magnitude, Local Extent, Medium-term Duration, and Fully Reversible. Given that and given that the LSA is currently moderately disturbed by existing activities, the effect of change in Human Health is predicted to be **Not Significant.**

The Level of Confidence is **High** as a quantitative assessment was completed using Project-specific and receptor-specific information where possible.

5.5 Summary of Project-related Residual Adverse Effects and Significance

The following residual effects of the Project on the Human Health VC were assessed:

- changes in Human Health due to Project-related changes in air quality from CACs;
- changes in Human Health due to Project-related changes in metal COPC concentrations in environmental media;
  - non-Carcinogenic COPCs (all pathways);
  - carcinogenic COPCs (ingestion pathway); and
- changes in Human Health due to Project-related increases in noise levels.

Table 5.5-1 summarizes the results of the assessment of the residual effects of the Project on the Human Health VC.

The residual effects of the Project on the Human Health VC were predicted to be **Not Significant**. Considering this, the Project effects are not expected to alter the integrity of the Human Health VC within the LSA beyond an acceptable level.

All residual effects are carried forward into the CEA.

Table 5.5-1: Summary of Residual Adverse Effects for Human Health Valued Component (VC)

Residual Adverse Effects	Contributing Activities within the Project Phases (C, O, D, P)*	Proposed Mitigation Measures	Residual Effects Characterisation								
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood	Significance	Level of Confidence
Changes in Human Health due to Project-related Changes in Air Quality from CACs	All activities (O)	▪ Limit Project footprint and Project Area ▪ Reclamation measures (refer to **RCP**) ▪ Transport measures ▪ Blasting measures (**EMP**) ▪ Dust suppression and air emissions (refer to **AQMP** and **MTCP**) ▪ Vehicle and equipment fleet selection and maintenance (**AQMP**) ▪ Wood or oil stove replacement program	L	LSA	MT	FF	FR	L	UL	NS	H
Changes in Human Health due to Project-related Changes in Non-carcinogenic Metal COPC Concentrations in Environmental Media	All activities O, D, P	▪ Limit Project footprint and Project Area ▪ Reclamation measures (refer to **RCP**) ▪ Transport measures ▪ Blasting measures (**EMP)** ▪ Dust suppression and air emissions (refer to **AQMP** and **MTCP**) ▪ Management of ML/ARD (refer to **ML/ARDMP**) ▪ Management of hazardous materials and wildlife attractants (refer to **FMSCP** and **WMPRE** and **WMP**) ▪ People, employees, contractors, and onsite policies ▪ Public access management (refer to **PAMP**)	M	LSA	LT	IF	FR	L	UL	NS	M
Changes in Human Health due to Project-related Changes in Carcinogenic Metal COPC	All activities O, D, P	▪ Limit Project footprint and Project Area ▪ Reclamation measures (refer to **RCP**) ▪ Transport measures ▪ Blasting measures (**EMP**)	L	LSA	LT	IF	PR	L	UL	NS	M

Residual Adverse Effects	Contributing Activities within the Project Phases (C, O, D, P)*	Proposed Mitigation Measures	Residual Effects Characterisation								
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood	Significance	Level of Confidence
Concentrations in Environmental Media Other Than Air (Ingestion Pathway)		▪ Dust suppression and air emissions (refer to **AQMP** and **MTCP**) ▪ Management of ML/ARD (refer to **ML/ARDMP**) ▪ Management of hazardous materials and wildlife attractants (refer to **FMSCP** and **WMPRE** and **WMP**) ▪ People, employees, contractors, and onsite policies ▪ Public access management (refer to **PAMP**)									
Changes in Human Health due to an Increase in Ambient Noise Levels	All activities (O)	▪ Limit Project footprint and Project Area ▪ Transport measures ▪ Blasting measures (**EMP**) ▪ Vehicle and equipment fleet selection and maintenance (**AQMP**)	M	LSA	MT	CF	FR	M	L	NS	H

Notes: *C, O, D, P represent Project Phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure*
AQMP=Air Quality Management Plan (S13.0-C2); COPCs=Contaminants of Potential Concern; EMP=Explosives Management Plan (S13.0-C6); FMSCP= Fuel Management and Spill Control Plan (S13.0-C7); MTCP=Minesite Traffic Control Plan (S13.0-C10); ML/ARD=metal leaching/acid rock drainage; ML/ARDMP=Metal Leaching (ML)/Acid Rock Drainage (ARD) Management Plan (S13.0-C12); PAMP=Public Access Management Plan (S13.0-C14); RCP=Reclamation and Closure Plan (S13.0-C15); WMPRE=Waste Management Plan for Refuse and Emissions (S13.0-C20); WMP=Wildlife Management Plan (S13.0- C21).

Magnitude:	Low (L), Moderate (M), High (H)
Geographic Extent:	Project Area (PA), Local (LSA), Regional (RSA), beyond Regional (beyond RSA)
Duration:	Short-term (ST), Medium-term (MT), Long-term (LT)
Frequency:	Infrequent (IF), Frequent (FF), Continuous (CF)
Reversibility:	Fully reversible (FR), Partially reversible (PR), Irreversible (IR)
Context:	Low (L), Moderate (M), High (H)
Likelihood:	Unlikely (UL), Likely (L)
Significance:	Not-Significant (NS), Significant (S)
Level of Confidence:	High (H), Moderate (M), or Low (L)

Please refer to **Table 5.1-2 for list of applicable activities for each listed Project phase, unless otherwise noted in this table.*

6. CUMULATIVE EFFECTS ASSESSMENT (CEA)

Cumulative effects are changes to the environmental, economic, social, heritage and health values and Indigenous interests caused when the Project's adverse residual effects combine with the adverse residual effects of other past, present and reasonably foreseeable future projects and activities. This subsection will assess cumulative effects on the Human Health VC.

Residual effects (from **Table 5.5-1**) will be assessed for cumulative effects. As outlined in **5.4**, the following Project-related residual effects on the Human Health VC were considered for their potential to interact cumulatively with the same residual effects of other projects and activities:

- changes in Human Health due to Project-related changes in air quality from CACs;
- changes in Human Health due to Project-related changes in metal COPC concentrations in environmental media;
  - non-carcinogenic COPCs (all pathways);
  - carcinogenic COPCs (ingestion pathway); and
- changes in Human Health due to Project-related increases in noise levels.

The spatial extent of the Project residual effects on Human Health were limited to the LSA and were more generally limited to the waterways and terrestrial environment closest to the Project. Residual effects were not predicted to extend to the Bulkley River (from aquatic exposure routes) or beyond a short distance (Figures 5.2-1 to 5.2-6 in **S4.0-C1**) from the Minesite or roads (from dust and terrestrial exposure routes). For the purposes of the cumulative effects assessment, only past, present, or reasonably foreseeable projects or activities with spatial and temporal overlap with the Project residual effects were considered further.

All past, present, and reasonably foreseeable future projects and activities identified in the Project and Activity Inclusion List (**S3.0 Assessment Methodology** of the **EAC Application**) were considered. Projects and activities located within the spatial boundaries of the Human Health LSA (the extent to which residual effects are confined) are shown in **Table 6-1** and **Figure 6-1**. Other projects and activities listed in the Project and Activity Inclusion List are not anticipated to have residual effects that overlap spatially and temporarily with Project-related residual effects on the Human Health VC and are not included.

The temporal boundaries within which cumulative effects were considered include reasonably foreseeable future activities that occur over the life of the Project as defined in **3.2.4.2 Temporal Boundaries**. Potential effects due to present and past activities, such as mineral exploration, agriculture, and forestry, have been addressed within **5. Assessment of Project-Related Effects** and are not separately considered in the CEA because the existing conditions (Base Case) and Project predictive models took into account past and present disturbances.

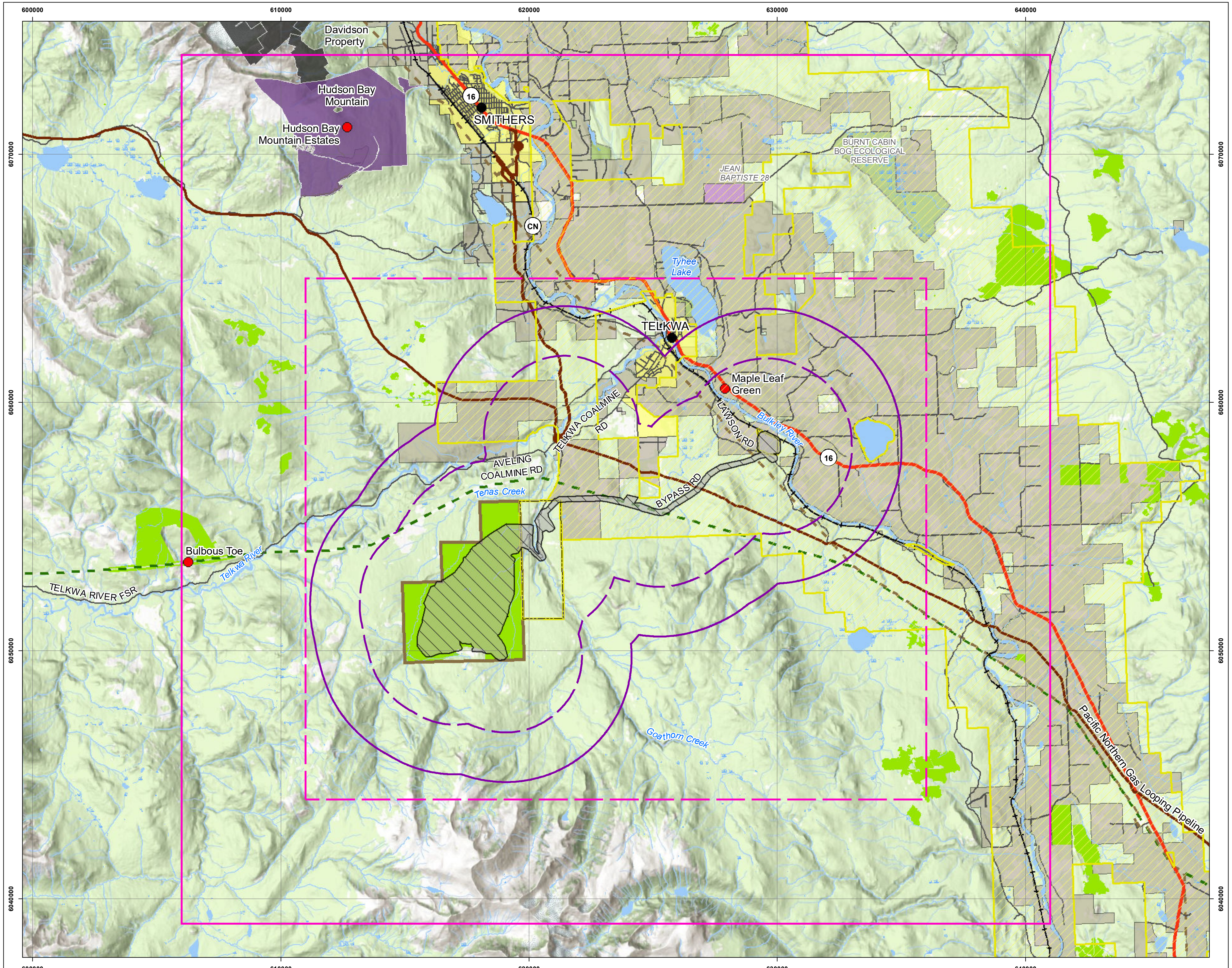
Potential cumulative effects on Human Health are discussed in the following subsections.

Table 6-1: Projects Included in the Assessment of the Human Health Valued Component (VC) Based on Spatial and Temporal Interaction

Project/Activity Name	Interacts with Project-related Effects on the VC as a Past, Present, or Future Project/Activity	
	Past and Present	Future
Bulbous Toe	Yes	Yes

Project/Activity Name	Interacts with Project-related Effects on the VC as a Past, Present, or Future Project/Activity	
	Past and Present	Future
Maple Leaf Cannabis Production Facility	No	Yes
Pacific Northern Gas Looping Pipeline	Yes	Yes
Telkwa to Smithers Bike Trail	No	Yes
Community Development	Yes	Yes
Agricultural Activities	Yes	Yes
Forestry Activities	Yes	Yes
Harvesting Activities	Yes	Yes
Recreation Activities	Yes	Yes

Notes: *Project=Tenas Project; VC=Valued Component*



Tenas Project

Map of Projects and Activities for Cumulative Effects Assessment

Legend

- Project
- City/Town
- Rail Line
- Highway
- Road
- 138 kV Transmission Line
- 500 kV Transmission Line
- Watercourse
- Wetland
- Waterbody
- Park or Protected Area
- First Nation Reserve
- Municipal Area
- General Private Property
- Tenas Coal Licenses
- Telkwa Coal Limited Private Property
- Project Area
- Human Health Local Study Area
- Human Health Regional Study Area
- Noise Local Study Area
- Noise Regional Study Area
- Coastal GasLink Pipeline Ltd.
- Pacific Northern Gas Ltd.
- Pacific Trail Pipelines Management Inc.
- Telkwa to Smithers Bike Trail
- Hudson Bay Mountain Resort Tenure
- Mining Leases
- Agricultural Land Reserve (ALR)
- Forest Cutblock (Active or Pending)

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Project Area: Allegiance Coal, April 21, 2021
- Basedata: Government of British Columbia
- Basemap: World Topo Base

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TELKWA COAL LIMITED

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6.1 Cumulative Effects for the Human Health Valued Component (VC)

6.1.1 Potential Cumulative Effects

There is the possibility for cumulative effects resulting from Project residual effects overlapping with same effects of other projects and activities in the RSA. The following list provides a short description of each project / activity that has a potential to contribute to a cumulative effect on Human Health. As quantitative information is not available for most projects, the CEA was conducted qualitatively for those projects that warrant further consideration.

- Bulbous Toe: Bulbous Toe refers to a large slow-moving landslide near the western boundary of the Human Health RSA near the Telkwa River. The landslide continues to advance at approximately 30 centimetres (cm) per year and has a major transmission line traversing it. This slow-moving earth flow is not expected to result in air emissions that can overlap with Project effects (**S4.0-C1-6.1.1**); however, periodic maintenance activities and vehicle traffic have the potential to result in adverse residual effects on the **Surface Water** and **Atmospheric Environment VCs** (**S4.0-C3-6.1** and **S4.0-C1-6.1)**. However, as these activities are existing and ongoing, they have already been incorporated into the assessment of Base Case conditions and, thus, cumulative effects on the Human Health VC are not expected. In addition, cumulative effects on the **Groundwater VC (S4.0-C4-6.1**) or the Noise subcomponent of the **Atmospheric Environment VC** (**S4.0-C1-6.3.1**), which are linked to Human Health, are not expected for the Bulbous Toe;
- Maple Leaf Cannabis Production Facility: Maple Leaf Green World Inc. is developing a cannabis production facility at the Woodmere Nursery site, located southeast of Telkwa, approximately 2 km from the Rail Infrastructure:
  - The cultivation of cannabis plants is associated with emissions of VOCs. The key VOCs are natural substances including pinenes, linalool, myrcene, limonene, and isoprene (Wang et al. 2019). These substances are expected to be different from those that may be emitted by the Project and, therefore, any potential cumulative effects from inhalation of COPCs are not expected to overlap;
  - The construction of the facility and associated agricultural facilities have the potential to result in residual effects that interact cumulatively with the Project residual effects on the Surface Water VC and may result in an increased potential for change in water quality parameters through the change in land use and increase in runoff (**S4.0-C3-6.1**). However, residual Project-related effects on Human Health from changes in water quality do not extend to the Bulkley River, where the facility is going to be located, but are located closer to the Minesite **(5.4.3**). Therefore, cumulative effects on human health via the surface water pathway are not expected as there is no spatial overlap;
  - Cumulative effects on groundwater quality are not expected (**S4.0-C4-6.1**);
  - As the facility is 2 km from the Rail Infrastructure and over 150 m away from the nearest residence and noise levels are expected to remain below the BC OGC PSLs, cumulative effects of noise on Human Health at residences are not expected due to lack of spatial overlap with Project residual effects (**S4.0-C1-6.3.1**);
- Pacific Northern Gas Looping Pipeline: Pacific Northern Gas is proposing to upgrade its transmission pipeline capacity by looping or twinning its existing natural gas transmission system between Summit Lake and Kitimat. A portion of this 525 km pipeline corridor traverses through the Human Health LSA and RSA, including a compressor station, located approximately 2 km north of the Bypass Road that will need to be upgraded:

  - Stationary combustion sources at the compressor station may result in emissions of CACs, primarily nitrogen oxides (NO_X)[5] and small amounts of SO_2 and $PM_{2.5}$. Overlapping effects with past and present operations of the compressor station are expected to be included in the background concentrations developed for the assessment of Project effects. Future operations may increase ambient concentrations of NO_2 in the immediate vicinity of the compressor station. Cumulative effects are expected to remain below ambient air quality criteria and thus cumulative effects on air quality are not expected (**S4.0-C1-6.1.1**);
  - Cumulative effects on groundwater quality (**S4.0-C4-6.1**) and on surface water quality (**S4.0-C3-6.1**) are not expected;
  - Future operations of the compressor station may increase ambient noise levels in the immediate vicinity of the compressor station. Cumulative effects at the nearest residences are expected to remain below the BC OGC PSLs (**S4.0-C1-6.3.1**);
  - As there are no cumulative effects expected for VCs and subcomponents with direct linkages to the Human Health VC, cumulative effects on Human Health are also not expected;
- Telkwa to Smithers Bike Trail: The Cycle 16 Trail Society is intending to develop a paved cycling path that runs along Highway 16 and the Bulkley River between Telkwa and Smithers. Construction of the bike trail is anticipated to result in limited clearing and grubbing as well as a short-term increase in vehicle and equipment traffic:
  - The construction of this path (e.g., paving activities) may result in short-term emissions of CACs that can overlap temporally with Project effects. Spatial overlap is minimal as the contribution of the Project to CACs in Telkwa and beyond is less than 5% (**S4.0-C1-6.1.1**);
  - Construction activities may also have the potential to act cumulatively with the residual effects of the Project to surface water quality in the Bulkley River, resulting in a potential change to water quality parameters (**S4.0-C3-6.1**). However, these changes are expected to be negligible and do not overlap with the spatial extent of Project-related residual effects on Human Health from changes in water quality (see **5.4.3**);
  - Cumulative effects on groundwater quality are also not expected (**S4.0-C4-6.1**);
  - Construction may result in additional noise but overlapping effects of development of the bike trail is expected to be small compared to existing development included in the baseline noise levels (**S4.0-C1-6.3.1**);
  - No contribution to the cumulative effects on Human Health are expected from the construction of the bike trail;
- Community Development: Future community development in Telkwa, Smithers, and the Hudson's Bay Mountain Estates may result in additional emissions of CACs and potential changes in water quality associated with construction, municipal works, maintenance activities, residential heating, and vehicle traffic, etc. Effects on air quality, surface water quality, groundwater quality, and noise associated with future community development is expected to be small compared to existing development already included in the Base Case concentrations (**S4.0-C1-6.1, S4.0-C3-6.1, and S4.0-C4-6.1**). Contribution of the Project to cumulative effects is low or not detectable in the locations of potential future community development and, thus, community development is not expected to contribute to a cumulative effect on Human Health; and
- Agricultural, Forestry, Harvesting, and Recreation: These activities are ongoing and potential overlapping effects are expected to be included in the baseline concentrations for air quality,

[5] Emissions are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as nitrogen oxides (NO_X), with reactions in the atmosphere resulting in the conversion of NO to NO_2. Effects and indicators are based on ambient concentrations of NO_2.

surface water quality, groundwater quality, and noise. It is assumed that any future agricultural, forestry, harvesting, or recreational activities will likely result in similar effects to what has already occurred or is currently occurring and that are already incorporated into the Base Case data. Therefore, these projects are not expected to contribute to the cumulative effect on Human Health.

6.1.2 Additional Mitigation Measures

As potential cumulative effects on Human Health from emission of CACs and metals associated with other projects and activities are expected to be minimal, with limited spatial or temporal overlap, additional mitigation is not considered to be required to minimize cumulative effects on the Air Quality subcomponent of the **Atmospheric Environment VC (S4.0-C1-6.1.2)**.

Additional mitigation measures to those considered in the assessment of Project-related effects on the **Surface Water VC (S4.0-C3-5.3** and in **5.3** of this chapter**)** are also not considered to be necessary to avoid or minimize the predicted cumulative effects on Human Health from changes in surface water quality. It is assumed that the current and future projects and activities have appropriate environmental protection measures in place as required by laws and regulations to limit their potential effects within acceptable levels **(S4.0-C3-6.2).**

As potential cumulative effects on Human Health from groundwater associated with other projects and activities are not expected, additional mitigation is not considered to be required to minimize cumulative effects on the Groundwater Quality subcomponent of the **Groundwater VC (S4.0-C4-6.2.2).**

As potential cumulative effects on Human Health from noise associated with other projects and activities are expected to be minimal, additional mitigation is not considered to be required to minimize cumulative effects on the Noise subcomponent of the **Atmospheric Environment VC (S4.0-C1-6.3.2).**

6.1.3 Cumulative Effects and Characterisation of Significance

Table 6.1-1 provides a summary of residual effects of the Project in combination with those same residual effects of other projects and characterises the residual cumulative effects. As potential effects associated with other projects and activities are expected to be not detectable, the characterisation and rationale for cumulative effects for the Human Health VC is the same as the characterisation and rationale for Project-related residual effects.

Table 6.1-1: Summary of Cumulative Effects for the Human Health Valued Component (VC)

Cumulative Effects	Contributing Activities within the Project Phases (C, O, D, P)*	Cumulative Effects Characterisation								
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood	Significance	Level of Confidence
Change to Human Health due to Changes in Air Quality (Criteria Air Contaminants)	All activities (O)	L	LSA	MT	FF	FR	L	UL	NS	H
Changes in Human Health due to Project-related Changes in	All activities (O, D, P)	M	LSA	LT	IF	FR	L	UL	NS	M

Cumulative Effects	Contributing Activities within the Project Phases (C, O, D, P)*	Cumulative Effects Characterisation								
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood	Significance	Level of Confidence
Non-carcinogenic Metal COPC Concentrations in Environmental Media										
Changes in Human Health due to Project-related Changes in Carcinogenic Metal COPC Concentrations in Environmental Media other than Air (Ingestion Pathway)	All activities (O, D, P)	L	LSA	LT	IF	PR	L	UL	NS	M
Change to Human Health due to Changes in Noise Levels	All activities (O)	M	LSA	MT	CF	FR	L	L	NS	H

Notes: *C, O, D, P represent Project Phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure*
COPC=Contaminants of Potential Concern
Magnitude: Low (L), Moderate (M), High (H)
Geographic Extent: Project Area (PA), Local (LSA), Regional (RSA), Beyond Regional (beyond RSA)
Duration: Short-term (ST), Medium-term (MT), Long-term (LT)
Frequency: Infrequent (IF), Frequent (FF), Continuous (CF)
Reversibility: Fully reversible (FR), Partially reversible (PR), Irreversible (IR)
Context: Low (L), Moderate (M), High (H)
Likelihood: Unlikely (UL), Likely (L)
Significance: Not-Significant (NS), Significant (S)
Level of Confidence: High (H), Moderate (M), Low (L)
Please refer to **Table 5.1-2 for list of applicable activities for each listed Project phase, unless otherwise noted in this table. .*
*Includes all existing and reasonably foreseeable projects as outlined in **Table 6-1.***

6.2 Summary of Cumulative Effects Assessment (CEA)

The following residual effects of the Project on the Human Health VC were carried forward to the CEA:

- changes in Human Health due to Project-related changes in air quality from CACs;
- changes in Human Health due to Project-related changes in metal COPC concentrations in environmental media;
    - non-carcinogenic COPCs (all pathways);
    - carcinogenic COPCs (ingestion pathway); and
- changes in Human Health due to Project-related increases in noise levels.

Cumulative effects on the Human Health VC identified in the CEA were the same as the Project residual effects, as noted in **Table 6.1-1**. The Significance of the cumulative effects was determined to be **Not Significant** (**Table 6.2-1**), consistent with the conclusions of the Significance characterisation for Project residual effects.

Table 6.2-1: Summary of Cumulative Effects on the Human Health Valued Component (VC)

Potential Cumulative Effect	Contributing Activities within the Project Phases (C, O, D, P)*	Cumulative Effect (Yes/No)	Significant (Yes/No)
Change to Human Health due to Changes in Air Quality (CACs)	All activities that emit CACs (O)	Yes	No
Changes in Human Health due to Project-related Changes in Non-carcinogenic Metal COPC Concentrations in Environmental Media	All activities (O, D, P)	Yes	No
Changes in Human Health due to Project-related Changes in Carcinogenic Metal COPC Concentrations in Environmental Media Other Than Air (Ingestion Pathway)	All activities (O, D, P)	Yes	No
Change to Human Health due to Changes in Noise Levels	All activities that emit noise (O)	Yes	No

Notes: *C, O, D, P represent Project Phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure*
CACs=Criteria Air Contaminants
Please refer to **Table 5.1-2 for list of applicable activities for each listed Project phase, unless otherwise noted in this table.*
*Includes all existing and reasonably foreseeable projects as outlined in **Table 6.1-1.***

7. SUMMARY OF EFFECTS ASSESSMENT FOR THE HUMAN HEALTH VALUED COMPONENT (VC)

The Project has the potential to result in the following residual effects on the Human Health VC:

- changes in Human Health due to Project-related changes in air quality from CACs;
- changes in Human Health due to Project-related changes in metal COPC concentrations in environmental media:
  - non-carcinogenic COPCs (all pathways);
  - carcinogenic COPCs (ingestion pathway); and
- changes in Human Health due to Project-related increases in noise levels.

While all phases of the Project have the potential to result in effects on Human Health, the Operation Phase (for air quality and noise) and the Operation, Decommissioning and Reclamation, and Post-closure phases (for water quality) are predicted to have the greatest potential for effects. Residual effects on Human Health in these phases were modelled using a HHRA approach and upper-bound estimates of predicted environmental media concentrations (**Appendix 8.0-A**).

The Project will be designed to incorporate a number of mitigation measures. Other mitigation measures to be implemented during the Operation, Decommissioning and Reclamation, and Post-closure phases are based on BMPs, and proven or accepted mitigation used on other similar projects.

With mitigation measures in place, predicted residual effects of the Project on the Human Health VC were determined to be **Not Significant**.

Reasonably foreseeable projects in the area may have overlapping effects on the Human Health VC. However, based on the type and location of these projects and on the location and magnitude of Project residual effects on Human Health, overlapping effects are expected to be undetectable above current baseline concentrations and no additional mitigation measures are required. Therefore, the cumulative effects of the Project residual effects with the residual effects of past, present, and reasonably foreseeable projects and activities on the Human Health VC were also determined to be **Not Significant**.

8. FOLLOW-UP STRATEGY

Based on the results of the assessment, there are uncertainties where follow-up programs related to Human Health are recommended to confirm the results of the HHRA:

- concentration of CACs (PM_{10} and $PM_{2.5}$; as recommended in **S4.0-C1-8 Follow-up Strategy**);
- concentration of metals in soil;
- concentration of metals in berries or vegetation;
- concentration of metals in surface water (as recommended in **S4.0-C3-8 Follow-up Strategy**);
- concentration of metals in fish tissues; and
- concentration of metals in groundwater (as recommended in **S4.0-C4-8 Follow-up Strategy**).

Monitoring of POPC/COPC and POC/COC identified for aquatic life, wildlife, terrestrial vegetation, human health, and land uses will be conducted for soils, vegetation, sediment, and surface and groundwater.

There are already management plans proposed that will assist in the mitigation of Project effects (see **5.3**). Some specifically include Human Health-related monitoring and adaptive management, as follows:

- The **AQMP** will include the monitoring of PM_{10} and $PM_{2.5}$ and dustfall, as well as noise levels. To verify the accuracy of predicted residual effects and the efficacy of mitigation measures at receptor locations, it is recommended that the baseline air quality monitoring station located at PPR2 be maintained to collect continuous measurements of PM_{10} and $PM_{2.5}$ concentrations associated with the Project. The AQMP will include a TARP for Air Quality and for Noise. If ambient CAC concentrations, or noise levels, more than 40% above the predicted concentrations from dispersion modelling are observed, an investigation will be conducted to determine the cause of the exceedance, revisit administrative and operational controls to resolve the exceedance, and update mitigation and monitoring measures as needed to confirm effect of changes and the need for additional mitigation (see **AQMP**);
- The **Minesite Water Monitoring Program (Appendix 13.11-E)** of the **MWMP** will include monitoring of water quality in surface water at existing receiving environment locations and in groundwater at existing and proposed monitoring wells. A TARP for water quality in discharging facilities prior to discharge will be developed and implemented so that end of pipe water quality limits or threshold discharge rates are not exceeded. Monitoring results will be compared against Water and Load Balance Model results to verify conceptual models developed for water quality and Water and Load Balance Model updates will be performed if deviations from expected quality are noted;
- The **RCP** includes monitoring programs at Permanent Sample Plots (PSP) in background and reclaim sites to discern any potential contaminant issues through monitoring of soil and plant-tissue chemistry. Plant species potentially consumed by humans and/or other animals will be tested for element concentrations;
- A Subsistence Food Management Plan will be developed as part of the **RCP**, and in consultation with the Wet'suwet'en and relevant authorities. The plan will address potential effects of the Project on the change in access to land and the availability of subsistence foods. Details of the plan and associated monitoring to assess the actual effects and effectiveness of mitigation measures will be developed prior to reclamation (i.e., prior to Year 22); and

- The **VMP** will include measuring trace metal concentrations in vegetation and soil over time. Metals monitoring in vegetation will identify if plants are being affected by the Project and accumulating metals in their tissue (BC MEMLI 2021). Monitoring will be used to guide Project dust management and reclamation and will include measuring trace metal concentrations in vegetation and soil over time. Trace metals uptake will be monitored periodically (e.g., one (1) to five (5) years) during the Construction, and Operation phases (**S13.0-C18**). Annual reviews of the **VMP** will be completed to compare data, trends, and implementation of the **VMP**.

Any monitoring not included in the above plans that is recommended for Human Health (e.g., monitoring of COPC concentrations in fish tissue) is expected to be included under a Human Health Monitoring Program (HHMP) that is likely to be required by EAC Conditions[6]. It is anticipated that the HHMP will be developed and implemented in consultation with regulators, and Indigenous and non-Indigenous communities.

To the extent practical, the HHMP will incorporate and build on follow-up and monitoring proposed under other programs to provide consistency and reduce duplication of efforts. A HHMP will include adaptive management to limit and mitigate any unexpected Project residual effects on Human Health and will identify monitoring site locations and frequency/duration of monitoring not already proposed under other management plans. Monitoring will likely be required for Operation, Decommissioning and Reclamation phases, and may extend into the Post-closure Phase, depending on results.

[6] It is assumed that a Human Health Monitoring Program will likely be required prior to beginning Construction Phase for the Tenas Project because similar mining projects approved in BC in the last five years have also had this requirement included in their environmental assessment certificates.

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