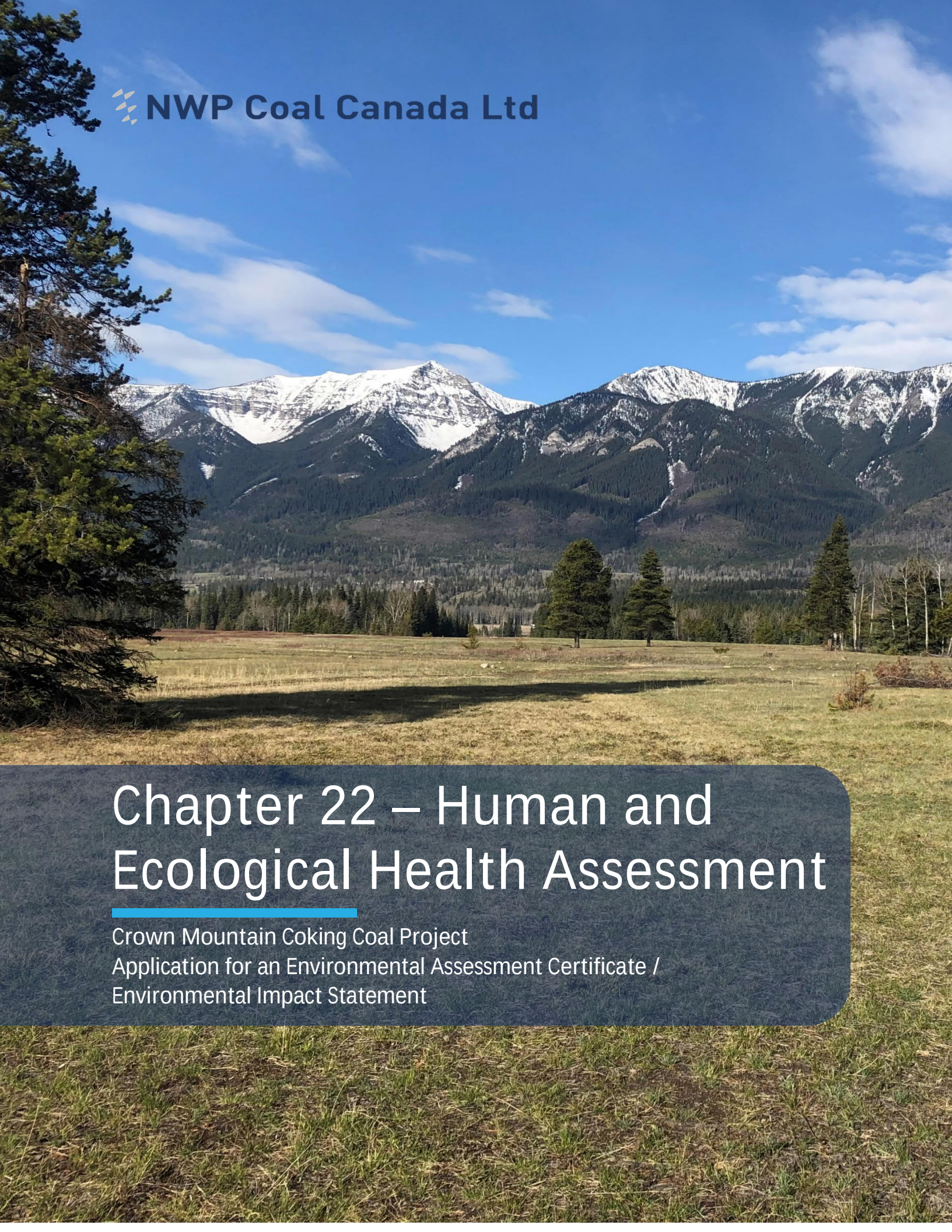

NWP Coal Canada Ltd

Chapter 22 – Human and Ecological Health Assessment

Crown Mountain Coking Coal Project
Application for an Environmental Assessment Certificate / Environmental Impact Statement

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Appendices

Appendix 22-A. Detailed Quantitative Environmental Risk Assessment
Appendix 22-B. Addendum to HHERA: Supplementary Assessment of Selenium Bioaccumulation Risk to Fish

22. Human and Ecological Health Assessment

22.1 Introduction

This chapter presents results of a prospective detailed quantitative human health and ecological risk assessment (HHERA) for the proposed NWP Coal Canada Ltd (NWP) Crown Mountain Coking Coal Project (the Project).

Major mining projects, such as the Project, have a potential to release chemical contaminants to the environment through controlled or uncontrolled releases such as permitted effluent discharge, surface water runoff, seepage, fugitive dust, and atmospheric emissions from vehicle traffic or other direct facility emissions, as described in earlier chapters of this Application/Environmental Impact Statement (EIS). These emissions and releases, in turn, have the potential to alter environmental quality of local and regional landscapes which could potentially expose humans and wildlife (including plants and animals in the terrestrial and aquatic environments) to chemical releases from the Project. The degree of exposure and the potential risks to human health, terrestrial wildlife health, aquatic wildlife health (e.g., fish, amphibians, invertebrate communities, water birds) are of concern to local residents, communities, and regulatory agencies, and are the focus of this chapter.

Human health risk assessment (HHRA) and ecological risk assessment (ERA) are systematic and well-documented processes to define and quantify potential health risks, which in the present instance serve as surrogate measures of potential health impacts from the Project. Health risks are expressed using various numerical expressions or indices that inherently combine the concepts of “likelihood to occur” and “type of health effect” to which protection is being afforded. Detailed description of methods and modelling results are reported in the technical support document on human health and ecological risk assessment (AECOM, 2021; Appendix 22-A).

22.1.1 Regulatory and Policy Setting

Since the proposed Project is a coal mine with a proposed capacity greater than 250,000 tonnes per year of clean coal and will result in a disturbance greater than 750 hectares (ha) that was not previously permitted for disturbance, it is subject to a provincial environmental assessment (EA) under Part 3 of the Reviewable Projects Regulation (2019) of the British Columbia (B.C.) Environmental Assessment Act (EAA, 2002).

The B.C. Environmental Assessment Office (EAO) issued a Section 10 Order to the Proponent on October 30, 2014, confirming that the proposed Project requires an Environmental Assessment Certificate (EAC), pursuant to Section 10(1)(c) of the EAA, before it may receive provincial permits to construct and operate the proposed Project.

The EAA (2002) was repealed by the EAA (2018) in 2019. As per subsection 78(6) of the EAA (2018), the EA process for the Project was continued under the 2002 Act. On May 3, 2023, the Project was transitioned to the EAA (2018) through a Transition Order under Section 78(7) of the 2018 Act.

The proposed Project is also subject to the Canadian Environmental Assessment Act, 2012 (CEA Act, 2012). Federally, the Project is considered a "Designated Project" under the Regulations Designating Physical Projects under the CEA Act, 2012 as the mine will have a production capacity of more than 3,000 tonnes per day.

The HHERA was conducted in general accordance with the following federal and provincial technical/policy guidance documents:

- Federal contaminated sites risk assessment in Canada part 1: Guidance on human health preliminary quantitative risk assessment (PQRA) (Health Canada, 2010a);
- Federal contaminated site risk assessment in Canada, part V: Guidance on human health detailed quantitative risk assessment for chemicals ($DQRA_{Chem}$) (Health Canada, 2010b);
- Ecological risk assessment guidance document (Canadian Council of Ministers of the Environment [CCME], 2020); and
- Protocol 1 for contaminated sites: Detailed risk assessment (British Columbia Ministry of Environment and Climate Change Strategy [ENV], 2021).

22.2 Scope of the Assessment

All chemical substances/stressors (from both anthropogenic and natural sources) have the potential to cause environmental effects. The magnitude of risk depends on: (i) "receptors" being present (e.g., people or wildlife); (ii) an operative exposure pathway being present to allow receptors and contaminants to interact; and (iii) a contaminant of potential concern (COPC) being present at a concentration sufficient to be hazardous.

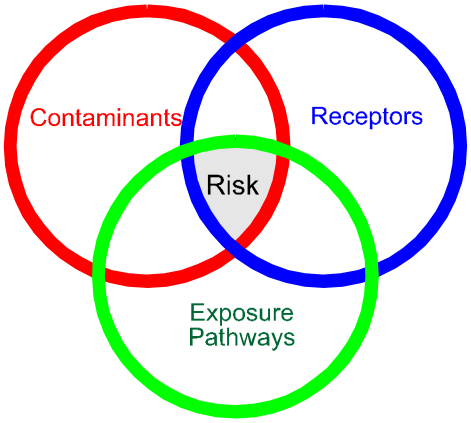

Illustration 22.2-1:
Components of a Toxicological Risk

Where all three components are present, the possibility of a health risk theoretically exists (see Illustration 22.2-1). The process of describing the possible combinations of receptors, exposure pathways, and COPCs is the basis of risk assessment Problem Formulation and applies in the present evaluation. Problem Formulation only considers the risk conceptually or qualitatively (i.e., is the component present or absent?) and there are no mathematical calculations at this stage. If one or more of these three components is absent, then the risk is negated. This would be equivalent to one of the three circles being removed, thereby eliminating the central overlapping region of "risk". In other instances, all risk components may be present, and it may then be necessary to mathematically calculate the amount of exposure that people or wildlife experience to understand if the risk is acceptable or not acceptable. For example, a receptor could be exposed to a chemical, but if that chemical has negligible toxicity and/or is present at only very low (i.e., non-hazardous) levels, then no unacceptable risk would be expected. One can envision therefore, that as exposure and/or toxicity of substances increases, the health risk may also increase and possibly reach an unacceptable level. And the goal of risk assessment is to examine all such scenarios.

The major components of the risk assessment framework for this HHERA include the following:

- Problem Formulation: A review and compilation of existing data and a qualitative summary of the prevailing and anticipated risk components. Identification of the environmental hazards that may pose a human health or ecological risk (i.e., contaminants of potential concern exceeding applicable guidelines), potential receptors, and relevant exposure pathways;
- Exposure Assessment: Qualitative and/or quantitative evaluation of the degree to which the receptors are exposed to the hazard in relation to expected exposure scenarios;
- Toxicity Assessment: Establish the toxicological relationship between assessed contaminants and receptors. Identify what potential effects the contaminant has on the receptor and at what concentration or level of exposure;
- Risk Characterization: Qualitative and/or quantitative assessment of the human health or ecological risk of each potential COPC to each receptor. Risk characterization integrates the exposure with potential effects; and
- Uncertainty Assessment: Review of the assumptions and uncertainties associated with the risk estimation, along with an evaluation of the extent to which conclusions about risks are sensitive to assumptions and limitations.

The methods for establishing the ecological and human health risks are focused on a systematic approach whereby exposure point concentrations are used to derive an estimated exposure, and then the estimated rate of exposure to a substance is compared to a reference (threshold) value of exposure that is known to be safe. This comparison of the estimated rate of exposure to a safe rate of exposure is then expressed numerically as a quotient (i.e., hazard quotient, or HQ), or as a probability in the case of cancer-causing substances (i.e., incremental lifetime cancer risk, or ILCR). The general approach is as follows:

- Establish receptor exposure scenarios including receptor characteristics, exposure locations, and exposure pathways;
- Establish exposure point concentrations either through empirical observation or environmental modelling;
- Estimate exposure to receptors as a result of either direct contact with abiotic media, or as a calculated internalized dose;
- Compare exposure estimates to toxicity reference values determined as part of the toxicity assessment to determine risk estimates; and
- Interpret risk estimates as to their significance in consideration of uncertainties, conservatism included in the assessment, geographic extent, reversibility, likelihood of effect, etc.

22.2.1 Valued Components and Measurement Indicators

All valued components (VCs) addressed within the HHERA are "receptor VCs" and in this context the potential impact (health risk) being assessed is linked to "intermediate VCs" such as the abiotic media soil/water/sediment/air quality, which provided a key basis for exposure point concentrations. Additional linkages between Project VCs addressed inherently within the HHERA are the linkages of contaminant exposure facilitated by animals and plants which people and wildlife consume (i.e., VCs linked within food chains).

VCs were identified through stakeholder consultation and consideration of past EA submissions for similar projects in Elk Valley and are presented in the Crown Mountain Coking Coal Project – Valued Components for Environmental Assessment submitted to B.C. EAO (EAO, 2018). VCs to which the present assessment relate primarily include:

- Wildlife Health – Wildlife species assessed directly or through consideration of surrogate VCs were American Robin, little brown bat, masked shrew, White-tailed Ptarmigan, least chipmunk, snowshoe hare, bighorn sheep, elk, Common Raven, deer mouse, grizzly bear, Northern Goshawk, American badger, American marten, Canada lynx, American Dipper, Canada Goose, moose, Common Merganser, and river otter;
- Aquatic Health – Benthic invertebrates, fish species, amphibians, and aquatic feeding wildlife such as waterbirds; and
- Human Health – People, including local communities, Indigenous communities, and temporary residents at recreational areas.

The fundamental Key Question (KQ) respecting potential risk (impacts) to the VCs of ecological and human health in relation to the Project's Local Study Area (LSA) and Regional Study Area (RSA) is:

- KQ1: What will be the collective effect of changes to water, air, soil, and food caused by the Project to (i) ecological health, and (ii) human health?

Figure 22.2-1 illustrates the relationship of the Key Question on which data analyses and modelled exposure scenarios were structured. It was assumed that potential health risk associated with optimal production during the mine Operations phase would result in higher chemical exposures than the Construction and Pre-Production, Reclamation and Closure, and Post-Closure phases, given the nature of the activities during those phases; hence, the HHERA focused on Operations phase scenarios as a conservative measure. The rationale is that maximum operational productivity would have more air emissions, truck/rail traffic, and treated wastewater release than the other phases, and therefore assessing the Operations phase would be the more conservative scenario by which to evaluate the Project risks to ecological and human health.

Terrestrial Wildlife as Valued Components: Terrestrial wildlife species and groups that were selected as VCs for the Project were based on the approved Applications Information Requirements (AIR) for the Project (EAO, 2018). Candidate VCs selected for the assessment and the rationale for selection of surrogate receptors of concern (ROCs) used to assess the VCs are provided in Table 22.2-1. Assessment Endpoints and Measurement Indicators are then provided in Table 22.2-2. The effects of noise and vibration on wildlife receptors is assessed in Chapter 7.

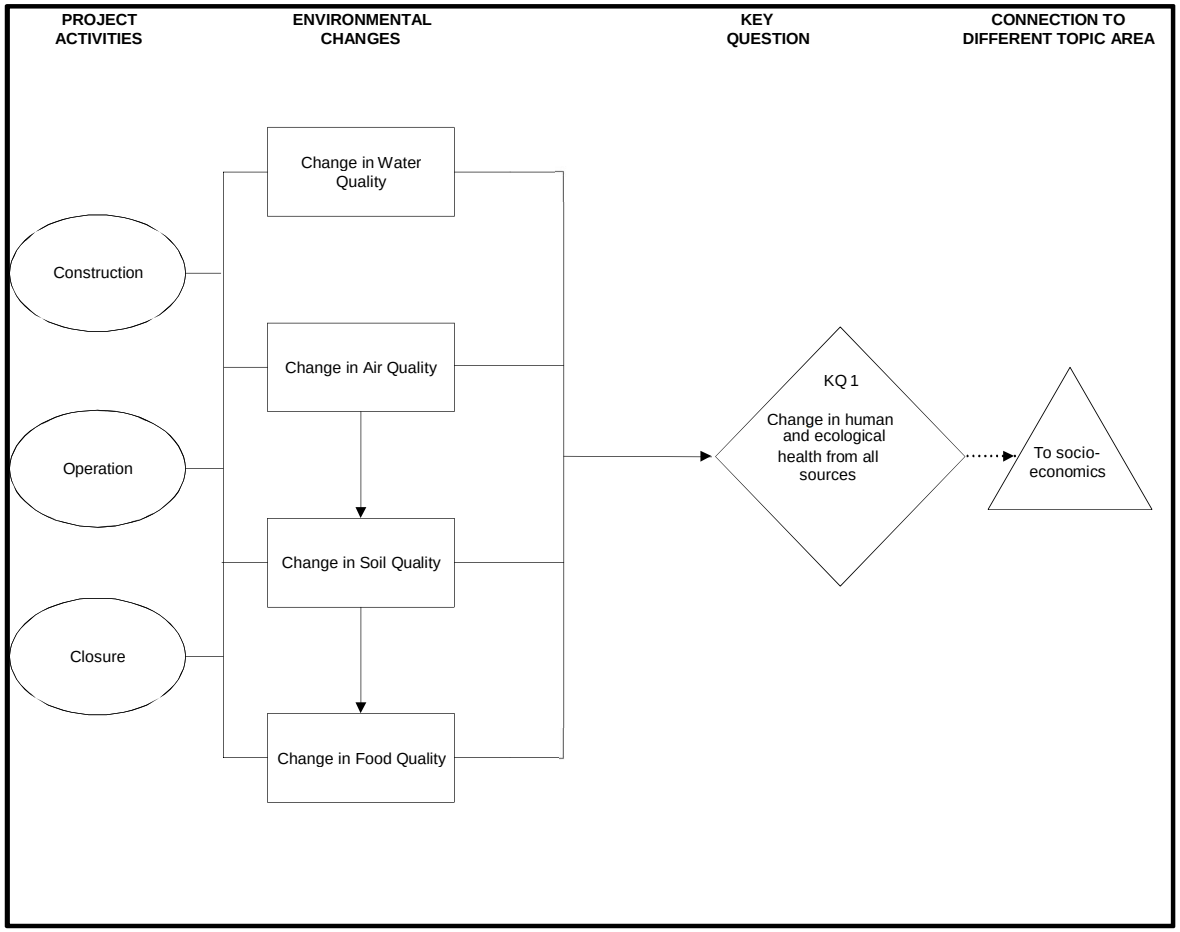

Figure 22.2-1: Linkage Diagram with Interrelationships of General Key Question for HHERA

Table 22.2-1: Valued Components, Receptors of Concern, and Surrogate Receptors Assessed in the Wildlife Health Risk Assessment

Receptor Group	Receptor Type	Included in Ecological Risk Assessment (ERA)? (Yes/No)	Rationale	Receptors of Concern (ROCs)*	Surrogate ROC(s) (if applicable)
Primary Producer	Moss / Grass / Shrub / Tree / Forb	Yes	A range of vegetation is present within the HHERA LSA/RSA including lichen, mosses, grasses, wildflowers, willow, and ground shrubs.	Lichens, mosses, grasses, wildflowers, willow, ground shrubs	Terrestrial plants (Community)
Invertebrate	Ground-dwelling	Yes	Ground-dwelling invertebrates are expected to be present in areas of accumulated soil and are an important dietary component for higher trophic level receptors.	Soil invertebrates	Soil invertebrates (Community)
	Aerial	No	Aerial invertebrates are likely present at the site. However, their contact with soil COPCs is considered negligible. (Larval form will be considered with ground-dwelling invertebrates.)	Not Applicable	Not Applicable
Mammal	Herbivorous	Yes	Herbivorous mammals have the potential to be found throughout the LSA/RSA, including ungulates, hares, and small rodents.	• Bighorn sheep • Mountain goat • Deer mouse • Elk • Least chipmunk • Moose • Snowshoe hare	• Bighorn sheep • Deer mouse • Elk • Least chipmunk • Moose • Snowshoe hare

Receptor Group	Receptor Type	Included in Ecological Risk Assessment (ERA)? (Yes/No)	Rationale	Receptors of Concern (ROCs)*	Surrogate ROC(s) (if applicable)
			Ungulate Winter Range occurs across valley bottoms and warm aspect hillsides and are important for elk. Bighorn sheep are Blue-listed in B.C.		
	Insectivorous	Yes	Insectivorous mammals, such as bats, have the potential to be found within the LSA/RSA. The little brown bat, northern myotis, and eastern Red Bat are of special conservation concern and have been impacted by White Nose Syndrome. Both the northern myotis and little brown bat are listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and are Blue and Yellow-listed (respectively) in B.C. The eastern red bat is Red-listed in B.C.	• Little brown bat • Northern myotis • Eastern red bat	Little brown bat

Receptor Group	Receptor Type	Included in Ecological Risk Assessment (ERA)? (Yes/No)	Rationale	Receptors of Concern (ROCs)*	Surrogate ROC(s) (if applicable)
	Carnivorous	Yes	Carnivorous mammals have the potential to be found within the LSA/RSA, including furbearing mammals and shrews. Some furbearers have a high proportion of their diet coming from fish ingestion, which is a potential pathway for selenium uptake. American badger is Red-listed in B.C., and listed as endangered under COSEWIC and the Species at Risk Act (SARA). Presence of Canada lynx is an indicator of ecosystem health.	• American badger • Canadian lynx • Masked shrew • Northern river otter	• American badger • Canadian lynx • Masked shrew • Northern river otter
	Omnivorous	Yes	Omnivorous mammals have the potential to be found within the LSA/RSA, including American marten and grizzly bear. Grizzly bear were documented within the HHERA LSA during	• American marten • Grizzly bear	• American marten • Grizzly bear

Receptor Group	Receptor Type	Included in Ecological Risk Assessment (ERA)? (Yes/No)	Rationale	Receptors of Concern (ROCs)*	Surrogate ROC(s) (if applicable)
Avian			baseline surveys and are considered an important species both ecologically and socially. Grizzly bear is Blue-listed in B.C., and listed as Special Concern under COSEWIC and SARA. Baseline studies indicated that few American marten were found within the HHERA LSA.		
	Herbivorous	Yes	Herbivorous avian receptors may be present within the LSA/RSA. White-tailed Ptarmigan forage primarily on the ground increasing the likelihood of exposure to potential substances of interest.	White-tailed Ptarmigan	White-tailed Ptarmigan
	Carnivorous / Piscivorous / Insectivorous	Yes	Carnivorous / piscivorous / insectivorous birds have potential to be present within the LSA/RSA. Several of these are waterbird species. Northern Goshawk is Blue-listed in B.C.	• American Dipper • Common Merganser • Harlequin Duck • Northern Goshawk	• American Dipper • Common Merganser • Harlequin Duck • Northern Goshawk

Receptor Group	Receptor Type	Included in Ecological Risk Assessment (ERA)? (Yes/No)	Rationale	Receptors of Concern (ROCs)*	Surrogate ROC(s) (if applicable)
	Omnivorous / Insectivorous	Yes	Omnivorous / insectivorous birds have potential to be present within the LSA/RSA. Several of these are waterbird species.	• Canada Goose • Common Raven • Mallard • Red-winged Blackbird • Spotted Sandpiper • American Robin	• Canada Goose • Common Raven • Mallard • Red-winged Blackbird • Spotted Sandpiper
Reptile	Carnivorous	No	Sensitive reptile species, such as the western painted turtle, have a low potential of occurring within the Project footprint and HHERA LSA.	Not Applicable	Not Applicable

Note:
* As defined in Applications Information Requirements for the Project (EAO, 2018)

Table 22.2-2: Assessment Endpoints and Measurement Indicators for Wildlife Health Assessment of Valued Components

Valued Components	Assessment Endpoint	Measurement Indicators
Primary Producers	Protection of plant health to foster sustained growth, reproduction and populations.	Hazard Quotient using exposure input from predicted and/or measured soil quality, including deposition of metals in dustfall.
Soil Invertebrate	Protection of invertebrate community health to foster sustained growth, reproduction and populations.	Hazard Quotient using exposure input from predicted and/or measured soil quality, including deposition of metals in dustfall.
Wildlife (Mammalian)	Protection of wildlife health to foster sustained growth, reproduction and populations.	Hazard Quotient using exposure input from predicted and/or measured soil quality (including deposition of metals in dustfall), surface water quality, sediment quality, and food quality.
Wildlife (Avian)	Protection of wildlife health to foster sustained growth and reproduction.	Hazard Quotient with input from predicted and/or measured soil quality (including deposition of metals in dustfall), surface water quality, sediment quality, and food quality.

Aquatic Wildlife as Valued Components: Aquatic wildlife species and groups that were selected as VCs for the Project were based on the approved AIR for the Project (EAO, 2018). Candidate VCs selected for the assessment and the rationale for selection of surrogate ROCs used to assess the VCs are provided in Table 22.2-3. Assessment Endpoints and Measurement Indicators are then provided in Table 22.2-4.

Table 22.2-3: Identified Valued Components and Surrogate Receptors of Concern Used in the Aquatic Health Risk Assessment

Valued Component	Included in ERA? (Yes/No)	Rationale	Receptors of Concern (ROCs)	Surrogate ROC(s) (if applicable)
Aquatic Life	Yes	Aquatic life has been selected as a ROC via indirect fate and transport to surface water bodies supporting aquatic life. Benthic invertebrates are known to live in sediment or on the bottom of waterbodies within the HHERA LSA. Benthic invertebrates may be affected by changes in surface water quality and quantity, sediment quality, as well as groundwater (e.g., quality and quantity of groundwater flows).	• Benthic invertebrates • Periphyton	Benthic invertebrates
Amphibians	Yes	Several amphibian species have the potential to occur within the HHERA RSA, including western toad, Rocky Mountain tailed frog, and the Columbia spotted frog.	Western toad	Amphibian Community

Valued Component	Included in ERA? (Yes/No)	Rationale	Receptors of Concern (ROCs)	Surrogate ROC(s) (if applicable)
Fish	Yes	Fish species within the HHERA RSA may be impacted by changes in surface water quality and quantity as well as sediment quality. Western Cutthroat Trout and Bull Trout are Blue-listed in B.C .and listed as Special Concern under SARA; Western Cutthroat Trout are also listed as Special Concern under COSEWIC. Bull Trout, Longnose Sucker, Mountain Whitefish, and Kokanee are important fish species for recreational fishing in the Elk Valley.	• Westslope Cutthroat Trout • Bull trout • Burbot • Longnose sucker • Mountain Whitefish • Kokanee	Fish Community
Waterbirds	Yes	For selenium assessment only, all waterbirds that are suspected of breeding in lotic or lentic environments within the HHERA LSA will be considered. Bird health may be affected by concentrations of selenium in aquatic prey.	• Red-winged Blackbird • Spotted Sandpiper • Mallard • American Dipper • Great Blue Heron	Waterbird Community

Table 22.2-4: Assessment Endpoints and Measurement Indicators for Aquatic Valued Components

Valued Components	Assessment Endpoint	Measurement Indicators
Aquatic Community (Benthic Invertebrates as ROC)	Maintenance of self-sustaining and ecologically effective populations.	Growth, survival, and reproduction of benthic invertebrates, assessed by comparison of predicted concentrations of water and sediment quality to screening values or benchmarks derived from literature-based toxicity information and that are protective of aquatic life
Amphibians	Maintenance of self-sustaining and ecologically effective populations	Growth, survival, and reproduction of benthic invertebrates, assessed by comparison of predicted concentrations of water and sediment quality to screening values or benchmarks derived from literature-based toxicity information and that are protective of aquatic life [(a)].
Fish	Maintenance of self-sustaining and ecologically effective populations	Growth, survival, and reproduction of fish, assessed by comparison of predicted concentrations of water and sediment quality to screening values or benchmarks derived from literature-based toxicity information and that are protective of populations of aquatic organisms.

Valued Components	Assessment Endpoint	Measurement Indicators
Waterbirds (Selenium Assessment Only)	Maintenance of self-sustaining and ecologically effective populations.	Growth, survival, and reproduction of waterbirds, assessed by comparison of predicted concentrations of selenium in water to screening values derived from literature-based toxicity information and that are protective of bird health.

Notes:
(a) Amphibian health may be affected by changes to surface water and/or sediment quality. Selenium mobilization is of particular concern with respect to coal mining activities in the Elk Valley. Selenium can lead to changes in reproductive health of egg-laying vertebrates. Available data suggest that amphibians are not more sensitive to selenium than fish and birds, and do not bioaccumulate selenium more than fish and birds. Therefore, a selenium benchmark based on the more sensitive of fish or birds is also expected to be conservatively predictive of potential effects on amphibians.

Human Health as a Valued Component: The AIR and the Guidelines for the Preparation of an Environmental Impact Statement for the Crown Mountain Coking Coal Project (EIS Guidelines; Canadian Environmental Assessment Agency, 2015) established that locally and regionally affected people and their associated health are receptor VCs warranting assessment of potential impact from the Project. In this regard, key considerations respecting this VC are local communities, Indigenous groups, and temporary residents (e.g., trapping or recreation cabins). Of the various groups of people who may visit the LSA/RSA in the future, people engaged in traditional land uses are expected to have the greatest frequency of potential exposure based on duration of visit and the activities they engage in while in the LSA/RSA. To this end, the HHERA focussed on various Indigenous land use and tradition lifestyles to conservatively assess maximal potential impacts to the VC of human health. By inference, potential impacts to human health of other peoples (e.g., non-Indigenous, recreational) would have less potential for a health risk.

- Assessment Endpoint: The assessment endpoint for human receptors is the toxicological benchmark that is considered to protective from any health effect to an individual over a lifetime of exposure. This benchmark is known in various terms as either the Tolerable Daily Intake (TDI) or the Reference Dose or Reference Concentration. For substances where theoretically, there is no exposure without effect (non-threshold substances), the assessment endpoint was benchmarked from the substance-specific potency reported by Health Canada.
- Measurement Indicators: For substances exhibiting a toxicological exposure threshold for effect, the measurement indicator is the hazard quotient (HQ; the ratio of the estimated exposure rate or dose compared to the safe benchmark exposure rate and expressed as a quotient). For substances exhibiting no theoretical threshold exposure for toxicological effects, the measurement indicator is the ILCR. Both human health measurement indicators are consistent with the AIR (EAO, 2018).

22.2.2 Indigenous and Stakeholder Consultation

Throughout the EA process, NWP engaged with Indigenous groups and conducted consultation with public stakeholders and regulators. Consultation and engagement activities are summarized and discussed in Chapter 4 of the Application/EIS.

Prior to development of the present HHERA, additional engagement took place with the Ktunaxa Nation Council (KNC) to provide traditional use and knowledge with respect to identification of critical receptor locations and characteristics to be included in the assessment of Human Health. A summary of feedback from the KNC specific to the HHERA is presented in Table 22.2-5.

Input from the KNC led to the HHRA adopting two fundamental Indigenous lifestyle profiles that reflect:

- Current land and resource usage ("Current Use" exposure scenario); and
- Indigenous rights-based land and resource usage ("Rights-Based Use" exposure scenario).

Most importantly, in both receptor scenarios, these considerations recognized KNC perspectives concerning frequency of traditional harvesting and hunting, dietary profiles, and interaction with environmental components of the HHERA LSA/RSA and this was integrated within exposure models for the human health risk assessment process.

Table 22.2-5: Summary of Engagement and Consultation Feedback on HHERA Input Parameters

Topic	Feedback Received*:				Consultation Feedback	Feedback Source	Response or Actions Identified
	IG	G	P/S	O			
Indigenous Human Receptor Age Groupings and Physiological Metrics	✓				Requirement for consideration of all members of societal composition (i.e., infant to elders)	Ktunaxa Nation Council (September 9, 2020)	Adoption of human receptor age groupings and physiological parameters per Health Canada (2010b)
Indigenous Human Receptor Traditional Dietary Profiles, and Critical Locations of Natural Resource Use	✓				HHRA needs to account for KNC to practice full rights-based traditional land based lifestyle including, location presence, frequency, traditional diet, and resource utilization.	Ktunaxa Nation Council (October 29, 2020)	Adoption of two Indigenous receptor groups for risk assessment: • Current Use • Rights-Based Use

Note:
*IG = Indigenous Group (group specified in column); G = Government (provincial or federal agencies); P/S = Public/Stakeholder (Interest group, local government, tenure and license holders, members of the public); O = Other

22.2.3 Assessment Boundaries

22.2.3.1 Spatial Boundaries

The spatial boundaries of the present HHERA and assessment of human and ecological health are dictated by the primary pathways potentially affecting environmental quality associated with Project-related emissions and releases, and are focused on the Project footprint, the HHERA LSA, and HHERA RSA, as discussed below. These include air quality and particulate matter deposition, as well as changes to surface water quality. The identified LSAs and RSAs for all biophysical disciplines relevant to the HHERA were reviewed prior to defining the HHERA LSA and RSA; this includes the Terrestrial Aquatic, Air Quality, and

Land Use and Tenure disciplines. As detailed in Chapter 5, Table 5.3-2, the spatial boundaries for the human health, aquatic health, and wildlife VCs have changed from the study areas presented in the AIR. A discussion on the spatial boundaries used in the assessment is provided below.

The Project footprint is the area of physical disturbance associated with the Project and encompasses all anticipated Project components, both temporary and permanent, covering approximately 13 square kilometres (km^2) or 1,283 ha. The centre of the Project is positioned approximately 12 kilometres (km) northeast of the District of Sparwood and approximately 5 km west of the provincial boundary between B.C. and Alberta. The Project footprint consists of the proposed surface extraction areas (three pits – North Pit, East Pit, and South Pit); Mine Rock Storage Facility; mine infrastructure and support facilities, including the plant area (raw coal stockpile area and processing plant); clean coal transportation route; rail loadout facility and rail siding; and ancillary facilities (i.e., water supply, power supply, natural gas supply, water, sewage treatment, fuel storage and explosives storage). The Project footprint is located within portions of two watersheds, Grave Creek and Alexander Creek. The majority of the Project footprint is located within the Alexander Creek watershed, while the access roads leading to the mine are generally located within the Grave Creek watershed.

Engagement with the KNC identified 15 critical human receptor locations (CRID1-CRID15) (Figure 22.2-2), as well as the anticipated frequency and duration of occupation of these areas. A quantitative assessment of risk was completed at all critical receptor locations to provide the assessment with the breadth of likely exposure scenarios individuals may experience within the HHERA LSA. While human receptors may engage other areas of the HHERA LSA or HHERA RSA, the range of exposure estimates generated as part of the KNC land use profile is anticipated to encapsulate any probable exposure scenario a human receptor is likely to encounter. It should be noted that CRID2, 4, and 12 are in the Project footprint (e.g., essentially on planned haul road shoulders or within the planned water treatment pond) and are therefore unlikely to remain as active CRIDs for traditional activities during the course of the mine life. For completeness, these CRIDs were assessed in the same manner as other CRIDs; however, the predicted exposure levels are highly influenced by conditions such as truck traffic safety and land use changes that will preclude traditional (and non-traditional) activities. Accordingly, exposure simulations are considered hypothetical scenarios.

Like the concept of critical human receptor locations (above), surface water quality at prediction nodes are explicitly considered for assessment of potential health risks to aquatic receptors (Figure 22.2-2).

The HHERA LSA was selected to incorporate overlapping portions of the relevant LSAs from other disciplines where modelling of changes to air and surface water quality were available. In addition, the spatial boundary of the assessment was informed by input from the KNC to incorporate identified areas of human traditional land use or occupation. The final HHERA LSA and RSA were defined as being equal to the Atmospheric LSA and RSA, as these spatial boundaries overlap with the LSAs and RSAs for all other relevant biophysical disciplines, and incorporate the geographic extent of critical human receptor locations (Figure 22.2-2) as well as diverse habitat and conservative exposure point concentrations for ecological VCs. The HHERA RSA is spatially equivalent to the RSA defined in the atmospheric environment assessment (Chapter 6); however, the HHERA does not specifically assess critical receptor locations outside of the HHERA LSA. Fate and transport mechanisms would result in attenuation of environmental exposure point concentrations in the RSA as compared to the LSA. Therefore, risk estimates within the LSA are inferred to be conservatively representative of risk estimates in the larger RSA.

Crown Mountain Coking Coal Project

Figure 22.2-2
Spatial Boundaries of the Human and Ecological Risk Assessment, Critical Receptor Locations, and Water Quality Prediction Nodes

LEGEND

- Receptor Location
- Water Quality Prediction Node
- Project Exclusion Zone
- Human Health Risk Assessment Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

0 2 4
Kilometres

Scale 1:115,000

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada. Imagery Provided By Landsat 8 (Aug 2018), and GeoBC Ortho Imagery (Aug 2016).

Map Created By: RB
Map Checked By: LKD
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2022-01-20

Document Path: \\42dillon\CAD\GIS\2012 and Prior\126231 Crown Mountain\EA_Report\EffectsAssessment\RiskAssessment\HumanHealth\126231_RAHH_SpatialBoundCritRecepLocsWQIPredictNodes.mxd

The combined/overlapping dataset of predicted environmental conditions due to proposed Project from other discipline teams in concert with the selection of locations known to be used by ecological receptors and important to human traditional land use means that the spatial boundary of the present HHERA includes the anticipated range of exposure conditions, including potential worst case conditions for both human and ecological VCs. The spatial boundary of the assessment was consistent between the human and wildlife receptors, and across the three scenarios of Baseline, Project, and Cumulative Cases evaluated in the effects assessment.

22.2.3.2 Temporal Boundaries

The anticipated production capacity of the Project is up to 4.0 million run-of-mine tonnes per annum for a production duration of approximately 15 years. The following key model phases have been used in the assessment and form the basis for the temporal boundaries:

- Operations phase: Mine Year 0 – 15;
- Reclamation and Closure phase: Mine Year 16; and
- Post-Closure phase: Mine Year 17 – 34.

The temporal boundaries for the present HHERA cover the life of the Project through Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure. The HHERA was conducted using conservative estimates of emissions as follows:

- For the air quality modelling (Dillon Consulting Limited [Dillon], 2021) on which the HHERA relies, emissions were modelled based on a five-year meteorological record and emissions estimates for the year of highest production (the eleventh year of mine operation and Year 13 of the Project). This emission rate was assumed to persist for the entire Construction and Pre-Production and Operations phases of the Project (i.e., the entire 15-year Project lifespan). Emissions are assumed to cease at the conclusion of the Operations phase; and
- For the surface water quality modelling (SRK Consulting Inc. [SRK], 2021a) on which the HHERA relies, predictions were developed for the entire 34-year Project lifecycle, including Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. The surface water quality model was parameterized based on anticipated mine production rates and disposition of mine rock during the Operations phase. The outputs of the water quality model carried forward for the present HHERA are based on the upper bound of source term concentrations (95th percentile), assuming the mine rock layering approach is successful at reducing oxidation of pyrite, thereby minimizing the release of sulphate, acidity, and trace elements including selenium and other metals.

For the human health risk assessment, it was conservatively assumed that people lived their entire lives within the HHERA LSA, spending 100% of their time at critical receptor locations. Since the air quality modelling and resultant incremental impacts to soil quality were developed based on the years of highest production (and therefore highest potential emissions), this is a conservative approach in line with Health Canada (2010a) guidance. Impacts associated with changes to surface water quality were assessed based on predicted annual peak concentrations (30-day rolling average) from the modelled time-series.

For wildlife receptors, the risk assessment was conducted based on conservative predictive modelling of emissions and consequent deposition to soil. The wildlife risk assessment evaluates chronic effects to wildlife receptors, assuming 100% of the receptors' time is spent within the spatial bounds of the

assessment, and that receptors would be exposed to conservative emissions estimates in the form of cumulative particulate deposition to soil, for their lifetime.

22.2.3.3 Administrative Boundaries

Administrative boundaries refer to the limitations imposed on the assessment by political, economic, or social constraints and consider the jurisdiction in which the Project is located. In addition to the applicable regulatory and policy framework previously, the Project is situated within the Designated Area of the Elk Valley Water Quality Plan (EVWQP; Teck Resources Limited [Teck], 2014a).

22.2.3.4 Technical Boundaries

Technical boundaries represent constraints imposed on the assessment due to limitations in the ability to predict the effects of the Project (EAO, 2013). Technical boundaries for the assessment of potential effects to human health and wildlife health include:

- Limitations imposed by the constraints of the baseline data collection, data coverage;
- Assumptions required in the predictive models that estimate future environmental quality of water, sediment, air, soil, and biological tissues relevant to use in HHERA exposure modelling;
- Compounding effects of the uncertainties incorporated in the various modelling outputs of the biophysical discipline teams which are incorporated into the exposure models of the HHERA; and
- Propagation of conservative assumptions employed in different fate/transport/exposure models to offset uncertainties noted above.

Aquatic health baseline data collected between 2017 and 2019 are considered representative of current conditions for the reaches of interest in Alexander and West Alexander Creeks, as there has been no change in mining activities since 2019 and these reaches have not been influenced by other operations. Mining influences within the Harmer and Grave Creek watersheds may have increased due to recent operational changes at Teck's Elkview Operations; however, these reaches will not be affected by effluent from the Project so changes to the conclusions of the HHERA are not anticipated. Michel Creek and the Elk River are located outside of the Fish and Fish Habitat LSA and within the Aquatic RSA. Mining influences within Michel Creek and the Elk River are anticipated to have changed due to operational changes at Teck's operations; however, as described in Chapter 11, Section 11.6.6.1, selenium loading in Michel Creek and the Elk River are predicted to be negligible and changes to the conclusions of the HHERA are not anticipated.

22.3 Regional and Local Overview

The biogeoclimatic zones of the Elk River area include elements of Montane Spruce, Interior Cedar-Hemlock, and Interior Douglas Fir. Prevailing conditions vary from undisturbed to areas of considerable disturbance associated with land use activities including: residential; recreational (e.g., hunting, all-terrain vehicle [ATV] trails, fishing, hiking, etc.); exploration; resource; industrial; rangeland; agriculture; and forestry. A biophysical overview of the regional and local area has been discussed previously (Chapters 12, 13, and 15) in context of watersheds and the reader is referred there for a more detailed description. Mining in the East Kootenay region has been ongoing for well over a century, with coal being the dominant resource extracted in the area. Additional information on past and present land uses is also provided in Chapter 1, Section 1.3.2. Collectively, the biogeoclimatic zones and variances in disturbances

dictate the type and quality of habitat for terrestrial/aquatic wildlife and local people that may be present as receptors, as described in subsequent sections.

As described in Chapter 10, the hydrologic conditions of the Aquatic LSA and Aquatic RSA are controlled by natural factors (e.g., climate; relief; geology; vegetation) and anthropogenic factors (e.g., mining; forestry; agriculture; hydroelectric dams; climate change). The Aquatic RSA for the Project is situated over the dividing line of Upper Kootenay Basin and the Central Kootenay Basin hydrologic zones (Zone Numbers 19 and 20, respectively). This area is characterized by low precipitation and dry summers, cold and dry winters, and low-to-moderate snowpack (Columbia Basin Trust, 2017). As noted in Chapter 10, Section 10.3, the Aquatic RSA is comprised of the full extents of the Elk River and extends downstream to include the portion of Lake Koocanusa located north of the Canada-United States of America (U.S.A.) border. The Elk River watershed covers an area of approximately 4,381 km^2 and is generally oriented in a north to south direction. The current land cover of the Elk River watershed is coniferous, shrub, and barren (68.4%, 14.8%, and 8.9%, respectively; FLNRORD, 2019).

22.4 Existing Conditions

22.4.1 Existing Regional and Local Information

The proposed Project is located in the East Kootenay Coal Fields, an area with a long history of mining exploration and extraction activities. Since 1898, more than 830,000 million tonnes of coal (most of it coking coal) has been produced from the Crowsnest and Elk River coalfields. Presently, coal mining operations are ongoing at Fording River, Greenhills, Line Creek, and Elkview Operations. The HHERA has considered regional and local information sources relevant to toxicological risk where available. This includes:

- The Elk Valley Water Quality Plan (Teck, 2014a) – The Elk Valley Water Management Plan provides detailed information on residual effects associated with coal mining in the Elk Valley. This includes derivation of toxicological reference values as well as determination of selenium bioaccumulation models relevant to the local environment. Teck Coal Limited (Teck) submitted the Area Based Management Plan (ABMP) - the "Elk Valley Water Quality Plan" on July 22, 2014. The Minister approved the plan on November 18, 2014;
- The Elk River Aquatic Environment Synthesis Report – Provides regional water quality data for the Elk Valley and provides the basis for identifying contaminants of concern to be addressed in the Elk Valley Water Management Plan;
- 2015 Ktunaxa Nation Diet Study – provided by Ktunaxa Nation, the dietary intake study provides a basis for parameterization of land use characteristics reflective of the local Indigenous community; and
- Ktunaxa Preferred Rates for Human Health Risk Assessments for Coal Mining Environmental Assessments within Qukin ʔamakʔis - provided by Ktunaxa Nation Council (August 24, 2020). The memorandum provides "preferred intake rates" determined based on the results of the 2019 Ktunaxa Nation Diet Study and engagement with Ktunaxa communities through 10 focus groups held during the fall of 2019. The preferred rates are amounts of Ktunaxa foods determined to support the needs of a Ktunaxa person, including but not limited to the nutrition needs.

For continuity with other local projects within the East Kootenay Coal Field and their regulatory review, the HHERA also considered quantitative risk assessments previously submitted and reviewed for similar projects within the Elk Valley. These include:

- Line Creek Operations Phase II Assessment Report (EAO, 2013);
- Fording River Operations Swift Project, Environmental Assessment Certificate Application (Teck, 2014b); and
- Elkview Operations Baldy Ridge Extension Project, Environmental Assessment Certificate Application (Teck, 2015).

22.4.2 Baseline (Risk Assessment) Studies

22.4.2.1 Methods

The Base Case represents existing conditions and characterizes potential for health risk to both human ecological receptors. The Base Case inherently incorporates effects to all environmental media from all existing development in the HHERA LSA such as existing mining operations, forestry, oil and gas exploration, etc. The Baseline assessment considers past and current effects from operating mining operations.

The Baseline assessment method is fundamentally as described in Section 22.2 and relies primarily on measured biophysical data, especially baseline studies of concentrations of contaminants of potential concern in environmental media and is conducted to establish current "benchmark risk estimates" in the form of either HQs of ICLRs. The Baseline benchmarks are subsequently used in the Project Case and Cumulative Case to examine the "incremental" risk resulting from releases associated with the Project and reasonably foreseeable future projects or activities. Documents from which Base Case information and data were obtained relevant to the development of the quantitative HHERA are as follows:

- Baseline Air Quality: Air Quality Baseline Report – Crown Mountain Coking Coal Project (Dillon, 2020a);
- Baseline Soil Data: Baseline Soil and Vegetation Chemistry Report – Crown Mountain Coking Coal Project (Keefer Ecological Services Ltd., 2021);
- Baseline Water Quality: Surface Water Quality Baseline Report: 2012 to 2019 Surface Water Quality Sampling Results – Crown Mountain Coking Coal Project (Dillon, 2020b);
- Baseline Sediment Quality: Crown Mountain Coking Coal Project – Aquatic Health Baseline Sampling Report (Lotic Environmental, 2020); and
- Baseline Fish Tissue Quality: Crown Mountain Coking Coal Project – Aquatic Health Baseline Sampling Report (Lotic Environmental, 2020).

In addition to use of baseline studies on environmental quality noted above, baseline food chain modelling was conducted to ascertain the baseline dietary exposure and risk to wildlife health and human health. Food chain modelling is described further under Section 22.5 and in detail in the technical support document on human health and ecological risk assessment (Appendix 22-A).

Table 22.4-1 provides an overview of the approach to baseline exposure point concentrations for modelling exposure of human and ecological receptors.

Table 22.4-1: Base Case - Fundamental Exposure Assessment Approach and Assumptions (AECOM, 2021)

Parameter	Base Case
Soil Quality	Not modelled; based on statistics of empirical baseline monitoring data.
Surface Water Quality	Not modelled; based on statistics of empirical baseline monitoring data.
Air Quality	Calculated using empirical baseline PM_{10} concentrations of 28 micrograms per cubic metre (µg/$m^{3)}$ (Dillon, 2021a) and its associated chemical composition (e.g., metals speciation) equal to average chemical composition of total particulate matter reported in baseline air quality monitoring program. PAHs in dustfall were not analyzed due to the volatility of these compounds.
Sediment Quality	95th percentile of baseline sediment quality dataset.
Fish Tissue	Baseline fish tissues for potentially affected stream reaches were modelled based on derived concentration ratios in conjunction with measured baseline water quality data. This approach was necessary to characterize baseline fish tissue concentrations in impacted stream reaches where fish tissue was not collected as part of the baseline assessment. For selenium, concentrations were modelled based on the Elk Valley selenium bioaccumulation model (Windward Environmental et al., 2014).
Fish Eggs	Calculated as a function of surface water concentration. Concentration ratios assumed to be equivalent to water-to-fish concentration ratios with the exception of selenium. Selenium concentration in fish eggs is predicted based on Elk Valley selenium bioaccumulation model.
Shellfish Tissue	Calculated as a function of baseline surface water concentration and literature derives water-to-crustacean concentration ratios.
Large Mammals	Modelled using intake calculated from food web model and literature derived transfer factor.
Small Mammal Tissue	Modelled using 95th percentile of baseline soil data and literature derived soil-to-whole organism concentration ratios for temperate small mammals.
Bird Tissue	Modelled using 95th percentile of baseline soil data and literature derived soil-to-whole organism concentration ratios for temperate avian receptors.
Bird Eggs	With the exception of selenium, concentration of COPCs in bird eggs is assumed to approximate the concentration in bird tissue and is calculated as a function of the 95th percentile of baseline soil quality dataset and soil-to-bird concentration ratios. Selenium concentration in bird eggs were modelled using the Elk Valley selenium bioaccumulation model (Windward Environmental et al., 2014) and the baseline surface water selenium concentration.
Berries	Modelled based on 95th percentile of baseline soil dataset and soil-to-berry concentration ratios.
Plant Roots	Modelled based on 95th percentile of baseline soil dataset and soil-to-shrub concentration ratios.
Other Plants	Modelled based on 95th percentile of baseline soil quality dataset and soil-to-plant concentration ratios.
Lichens and Mushrooms	Modelled based on critical receptor location specific predicted incremental soil concentration and soil-to-plant concentration ratios.

22.4.2.1.1 Threshold Criteria for Interpretation of Terrestrial and Aquatic Receptor Health Risk

Ecological risk assessment HQs are calculated using toxicity reference values (TRVs) that are intended to be protective of the receptors of concern and in consideration of the identified protection goals. As such, HQ values below one (1.0) indicate negligible potential for harm, whereas HQ values above one indicate that an adverse response is possible, and that more precise or accurate evaluation of risks may be warranted to address uncertainty. To provide interpretive insight on the risk levels and conservative assumptions employed to offset various sources of uncertainty normally encountered in ecological health risk assessment, the categories provided in Table 22.4-2 were used to describe the risk magnitudes for ecological receptors. This approach was applied for Baseline, Project, and Cumulative effects assessment.

Table 22.4-2: Categories of Magnitude of Effect in Wildlife Health Risk Assessment

Risk Estimate	Negligible	Low	Moderate	High
Hazard Quotient	No change, below applicable guidelines, or HQ ≤ 1.0	1.0 < HQ ≤ 5	5 < HQ ≤ 10	HQ > 10

22.4.2.1.2 Criteria Used for Interpretation of Human Health Risk

To provide interpretive insight on the significance of the risk levels and conservative assumptions employed to offset various sources of uncertainty normally encountered in health risk assessment, the following numerical categories (Table 22.4-3) were used to describe the risk magnitudes for non-carcinogenic and carcinogenic COPCs. This approach was applied for Baseline, Project, and Cumulative Cases for the effects assessment.

Table 22.4-3: Categories of Magnitude of Effect for Human Health Risk*

Risk Estimate	Negligible	Low	Moderate	High
Hazard Quotient (Non-carcinogens)	No change, below applicable guidelines, or HQ < 1.0	1.0 < HQ ≤ 5	5 < HQ ≤ 10	HQ > 10
ILCR (Carcinogens)	No change, below applicable guidelines, or ILCR < 1E-5	$1E^{-5}$ < ILCR ≤ $5E^{-5}$	$5E^{-5}$ < ILCR ≤ $1E^{-4}$	ILCR > $1E^{-4}$

Note:
* "E" is notation for 10 raised to the specified exponent value

In addition, risks are characterized to determine the potential for negative health effects or risks by considering the findings of the exposure and effects assessment and includes consideration of the significance of risk estimates and associated uncertainties. Risk characterization generally considers the following:

- Context – Are predicted risk estimates for the Project Case and Cumulative Case appreciably different than those calculated for the Base Case?
- Pathways – What are the primary pathways of exposure, and what uncertainties exist in the exposure assessment?

- Conservatism and Uncertainty in Predictions – What uncertainties exists in the predicted concentrations of COPCs in environmental media to which receptors are exposed? What are the sources of conservatism inherent in these predictions, and what effect are they likely to have on the predicted risk estimates?
- Conservatism and Uncertainty in Exposure Assumptions - What uncertainties exist in exposure assumptions carried forward for quantitative exposure assessment? What are the sources of conservatism inherent in these predictions, and what effect are they likely to have on the predicted risk estimates?
- Conservatism in TRVs – What conservatisms exists in the derived toxicity reference values, and what impact might this have on the risk estimates?
- Overall Significance of the Calculated Quantitative Risk Estimate – Based on the above risk characterization exercise, what is the overall significance of the calculated risk estimates?

22.4.2.2 Results

22.4.2.2.1 Baseline Terrestrial Wildlife Health

Baseline risk estimates (hazard quotients) for terrestrial wildlife are summarized below in Table 22.4-4, with hazard quotients that exceed a HQ of 1.0 in shaded cells. They indicate the following:

- Seven of 20 ecological receptors had baseline hazard quotients exceeding 1.0, the remaining receptors displayed risk estimates less than 1.0;
- Of those risk estimates exceeding 1.0, all but five are characterized as "low" (i.e., 1.0 < HQ ≤ 5); the remaining five estimates are characterized as:
  - Moderate for the Little Brown Myotis: HQselenium = 5.0; and
  - Moderate to High for the Masked Shrew: HQarsenic = 7.9 – 138;
- The baseline assessment was conducted based on a combination of empirical baseline data and modelled concentrations using the multi-media food web model. As such, baseline risk estimates incorporate much of the uncertainty present in the Project Case and Cumulative Case. Elevated risk estimates for some receptors are considered likely to be reflective of an artefact of the multimedia food web model; and
- The collective results suggest existing baseline chemistry as reported by baseline studies and then applied in conservative ecological food chain exposure models largely present negligible ecological health risk; but for certain species/diets with limited range and inhabiting precise locations, exposures to substances may present a borderline health risk. It is unlikely, however, that this presents a risk to the species population as a whole.

Table 22.4-4: Calculated Hazard Quotients (HQs) for Wildlife Receptors for the Base Case

Receptor	Arsenic (As)	Cadmium (Cd)	Cobalt (Co)	Chromium (Cr)	Selenium (Se)	Thallium (Tl)
American Badger	0.014	0.063	0.017	0.011	0.31	0.029
American Marten	0.19	0.77	0.14	0.11	4.2	0.3
Bighorn Sheep	0.015	0.011	0.0024	0.018	0.17	0.056
Canada Lynx	0.0000098	0.0032	0.0013	0.000064	0.013	0.0000014
Deer Mouse	0.53	1.8	0.015	0.13	11	0.41
Elk	0.0027	0.002	0.00043	0.0032	0.03	0.01

Receptor	Arsenic (As)	Cadmium (Cd)	Cobalt (Co)	Chromium (Cr)	Selenium (Se)	Thallium (Tl)
Grizzly Bear	0.00045	0.0013	0.0001	0.00027	0.02	0.0017
Least Chipmunk	0.21	0.49	0.016	0.13	3.5	0.39
Little Brown Myotis	0.21	0.8	0.0022	0.022	5	0.083
Masked Shrew	7.9	22	0.41	3.4	140	10
Moose	0.0014	0.0011	0.00025	0.0017	0.031	0.02
Northern River Otter	0.00085	0.019	0.00051	0.00075	1.3	0.072
Snowshoe Hare	0.1	0.045	0.016	0.12	0.55	0.36
American Dipper	0.12	2.4	0.048	0.19	Aquatic	0.074
Canada Goose	0.058	0.017	0.013	0.076	0.53	0.037
Common Merganser	0.0062	0.014	0.0013	0.0047	Aquatic	0.046
Common Raven	0.076	0.29	0.033	0.059	1.7	0.0084
Mallard	0.04	0.15	0.012	0.06	Aquatic	0.045
Northern Goshawk	0.00023	0.084	0.065	0.0029	0.32	0.0000018
White-tailed Ptarmigan	0.064	0.18	0.0095	0.07	1.2	0.01

Notes:
Shaded values indicated HQs in exceedance of HQ=1.0
Aquatic – Risks to aquatic waterbirds as a result of selenium exposure are considered in the aquatic wildlife health assessment. See Section 22.4.2.2.2

22.4.2.2.2 Baseline Aquatic Wildlife Health

Baseline risk estimates (Table 22.4-5) for the aquatic receptor VCs that inhabit the water column are based on empirical water quality data presented in the Surface Water Quality Baseline Report (Dillon, 2020b). Baseline hazard quotients are calculated to provide context to the results of the Project Case and Cumulative Case, and should not be considered definitive in terms of potential effect under baseline condition.

Key points of the baseline assessment of health risks to the aquatic health receptor VCs are as follows:

- Cadmium and Cobalt - despite a long history of mining in the East Kootenay Coal Fields , calculated baseline hazard quotients are below the threshold value of HQ=1.0 at all assessment locations for all receptor VCs;
- Selenium - aqueous selenium concentrations confer a potential risk to aquatic health under baseline conditions at some assessment nodes. Key points related to baseline selenium aquatic health risks are as follows:
    - Baseline risk indices for selenium are below the threshold value of HQ=1.0 at all assessment locations for all receptor VCs in the Alexander Creek Watershed. This includes all assessment nodes located in Alexander Creek and West Alexander Creek. Baseline risk estimates suggest negligible risk as a result of selenium exposure at these locations;
    - Baseline risk indices for selenium are below the threshold value of HQ=1.0 at all assessment locations for all receptor VCs in the upper reaches of Grave Creek (i.e., upstream of the confluence with Harmer Creek). Baseline risk estimates suggest negligible risk as a result of selenium exposure at these locations;

Table 22.4-5: Calculated Hazard Quotients (HQs) for Aquatic Receptor VCs Associated with Surface Water at Assessment Nodes for the Base Case

Location	Representative Assessment Nodes	Aquatic Community			Amphibians			Sensitive Fish Species			Waterbird
		Cd	Co	Se	Cd	Co	Se	Cd	Co	Se	Se
Lower Alexander Creek	AC_1	0.02	0.01	0.14	0.01	<0.01	0.05	0.01	<0.01	0.04	0
	AC_2	0.02	0.01	0.14	0.01	<0.01	0.05	0.01	<0.01	0.04	0
	AC_3	0.02	0.01	0.14	0.01	<0.01	0.05	0.01	<0.01	0.04	0
Upper Alexander Creek	AC_4	0.02	0.01	0.29	0.01	<0.01	0.11	0.01	<0.01	0.08	0.01
West Alexander Creek	AC_5	0.02	0.01	0.15	0.01	<0.01	0.06	0.01	<0.01	0.04	0
	AC_6	0.02	0.01	0.15	0.01	<0.01	0.06	0.01	<0.01	0.04	0
Elk River	ER1 [C]	0.03	0.05	1.71	0.01	<0.01	0.66	0.02	<0.01	0.45	0.04
Lower Grave Creek	GC_1 [C]	0.03	0.02	5.62	0.02	<0.01	2.16	0.02	<0.01	1.48	0.14
	GC_2 [C]	0.03	0.02	5.62	0.02	<0.01	2.16	0.02	<0.01	1.48	0.14
Upper Grave Creek	GC_3	0.02	0.01	0.46	0.01	<0.01	0.18	0.02	<0.01	0.12	0.01
Harmer Creek	GC_4 [C]	0.03	0.02	5.62	0.02	<0.01	2.16	0.02	<0.01	1.48	0.14
Upper Grave Creek	GC_5	0.02	0.01	0.46	0.01	<0.01	0.18	0.02	<0.01	0.12	0.01
	GC_6	0.02	0.01	0.46	0.01	<0.01	0.18	0.02	<0.01	0.12	0.01
	GC_7	0.02	0.01	0.46	0.01	<0.01	0.18	0.02	<0.01	0.12	0.01
	GC_8	0.02	0.01	0.19	0.01	<0.01	0.07	0.01	<0.01	0.05	<0.01

Notes:
Shaded cells indicate locations where baseline sediment data results in a calculated hazard quotient in excess of 1.0.
C = Locations inherently considered as cumulative assessment nodes as predicted water quality is influenced primarily by surface water source terms originating from other existing resource extraction projects.

- Harmer Creek and Lower Grave Creek (i.e., below the confluence with Harmer Creek) receive mine impacted water from the Teck's operations within the Harmer Creek catchment area. Baseline risk estimates suggest a low-to-moderate potential for risk to the Aquatic Community VC and a low risk to amphibians and sensitive fish species at assessment nodes impacted by Teck-related contaminant flux originating from the Harmer Creek watershed; and
- Concentrations of selenium in the Elk River are impacted by existing upstream activities within the Elk River Watershed. Baseline concentrations of selenium suggest a low risk to the aquatic community VC, and negligible risk to amphibians, sensitive fish species and waterbirds; and

- Locations where baseline risk estimates exceed the target threshold of HQ=1.0 are limited to areas known to be impacted by historical and ongoing mining activities and are not related to the proposed Project within the HHERA LSA.

Baseline risk estimates (Table 22.4-6) for the benthic invertebrate community VC are based on empirical sediment chemistry data collected as part of the baseline aquatic health sampling (Lotic Environmental, 2020). Baseline hazard quotients are calculated to provide context to the hazard quotients calculated for the Project Case and Cumulative Case and should not be considered definitive in terms of potential effect under Base Case condition.

Table 22.4-6: Calculated Hazard Quotients (HQs) for the Benthic Invertebrate Aquatic Community VC Associated with Sediment Contact at Assessment Nodes for the Base Case

Location	Representative Assessment Nodes	Aquatic Community (Benthic Invertebrates)		
		Cd	Co	Se
Lower Alexander Creek	AC_1	0.98	0.12	0.39
	AC_2			
	AC_3			
Upper Alexander Creek	AC_4	1.39	0.18	0.34
West Alexander Creek	AC_5	0.84	0.16	0.24
	AC_6			
Elk River	ER1 [C]	NA	NA	NA
Lower Grave Creek	GC_1 [C]	NA	NA	NA
	GC_2 [C]			
Upper Grave Creek	GC_3	1.38	0.18	0.41
Harmer Creek	GC_4 [C]	NA	NA	NA
Upper Grave Creek	GC_5	1.38	0.18	0.41
	GC_6			
	GC_7			
	GC_8			

Notes:
Shaded cells indicate locations where baseline sediment data results in a calculated hazard quotient in excess of 1.0.
NA = No baseline sediment data collected at these locations. Baseline risk estimates could not be calculated.
C = Locations inherently considered as cumulative assessment nodes as predicted water quality is influenced primarily by surface water source terms originating from other existing resource extraction projects.

Key points of the baseline assessment of health risks to the benthic invertebrate aquatic community VC are as follows:

- Cadmium - calculated baseline hazard quotients suggest a potential low (likely negligible) risk to benthic invertebrates associated with exposure to in Upper Grave Creek, and Upper Alexander Creek. These locations are generally not impacted by anthropogenic activities; and
- Empirical baseline sediment quality data from locations known to have been impacted by historical mining operations within the area (i.e., Lower Grave Creek and the Elk River) was not collected as part of the baseline studies for the current Project;
    - It is reasonable to assume that sediment quality in these areas will have been affected by effluent discharge from other coal extraction projects in the area and that calculated hazard quotients may exceed a value of HQ=1.0.

22.4.2.2.3 Baseline Human Health

Baseline risk estimates (HQs and ILCRs) for people under the two land use scenarios of either current use or "rights-based" use are summarized below in Table 22.4-7 and Table 22.4-8, with risk estimates that exceed threshold values in shaded cells. Maximal potential for exposure to COPCs is associated with the rights-based use scenario, owing to the elevated dietary intake of locally-sourced country foods (i.e., fish, game, berries, etc.) that is envisioned by local Indigenous peoples. The discussion of the Base Case HHRA results that follows is based on maximum calculated HQs, and as such derives from the rights-based use scenario. Risk estimates for all assessed receptors (current and rights-based use) are presented in Appendix 22-A. Risk estimates for the rights-based use scenario which predict a negligible or acceptable level of risk are therefore inherently protective of the current land use scenario and, by inference, protective of local non-Indigenous or recreational human receptors. Baseline risk estimates are calculated to provide context to the risk estimates calculated for the Project Case and Cumulative Case. Key results from the baseline human health assessment are as follows:

- Cadmium - risk estimates for non-cancer effects exceed the value of HQ=1.0 at a variety of locations;
    - All baseline HQs for cadmium are below 1.1;
- Cobalt and Chromium - risk estimates for non-cancer effects exceed a value of HQ=1.0 for at all locations assessed;
    - Maximum baseline risk estimates for cobalt and chromium are 1.3 and 1.7, respectively and considered low and likely negligible;
- Arsenic and Chromium - calculated ILCRs exceed the de minimis value of 1:100,000 (i.e., 1E-5) at all locations assessed;
- Baseline risk estimates are calculated based on a combination of empirical data and modelled concentrations following the methods used to assess risk in the Project and Cumulative assessment cases; and
- Hazard quotients greater than HQ=1.0 and ILCRs greater than 1E-5 are not indicative of an actual human health effect under current baseline conditions.

Table 22.4-7: Calculated HQs for Human "Rights-Based Use" Receptors at Critical Receptor Locations under the Base Case

Critical Receptor Location	Arsenic	Cadmium	Cobalt	Chromium	Nickel	Selenium
CRID #1	0.0024	0.999	1.18	1.72	0.674	0.00723
CRID #2	0.0025	1.02	1.23	1.73	0.669	0.00593
CRID #3	0.0024	0.999	1.18	1.72	0.674	0.00723
CRID #4	0.0024	0.999	1.18	1.72	0.674	0.00723
CRID #5	0.0024	0.999	1.18	1.72	0.674	0.00723
CRID #6	0.0025	1.02	1.23	1.73	0.669	0.00593
CRID #7	0.0024	0.999	1.18	1.72	0.674	0.00723
CRID #8	0.0024	1.05	1.28	1.74	0.666	0.00116
CRID #9	0.0024	1.05	1.28	1.74	0.666	0.00116
CRID #10	0.0024	1.05	1.28	1.74	0.666	0.00116
CRID #11	0.0024	1.05	1.28	1.74	0.666	0.00116
CRID #12	0.0025	1.02	1.23	1.73	0.669	0.00593
CRID #13	0.0024	0.999	1.18	1.72	0.674	0.00723
CRID #14	0.0024	1.05	1.28	1.74	0.666	0.00116
CRID #15	0.0024	1.05	1.28	1.74	0.666	0.00116

Notes:
Shaded values indicated HQs in exceedance of HQ=1.0
Hazard quotients presented represent maximum calculated hazard quotient of the various human receptors assessed for each critical receptor location.

Table 22.4-8: Calculated ILCRs for Human "Rights-Based Use" Receptors at Critical Receptor Locations under the Base Case

Receptor Location	Arsenic	Cadmium	Chromium	Nickel	Benzo[a]pyrene
CRID #1	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #2	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #3	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #4	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #5	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #6	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #7	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #8	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #9	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #10	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #11	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #12	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #13	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9

Receptor Location	Arsenic	Cadmium	Chromium	Nickel	Benzo[a]pyrene
CRID #14	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9
CRID #15	8.5E-4	6.0E-6	3.4E-5	5.6E-6	7.4E-9

Notes:
Shaded values indicated ILCRs in exceedance of 1:100,000
ILCRs presented are maximum composite ILCRs of the various human receptors assessed for each critical receptor location.

22.5 Project Effects Assessment

22.5.1 Thresholds for Determining Significance of Residual Effects

Threshold criteria for determining significance of residual effects for the Project effects assessment are the same as those previously described for the Base Case risk for terrestrial/aquatic receptors (Section 22.4.2.1.1), and for human receptors (Section 22.4.2.1.2).

22.5.2 Project Effects

22.5.2.1 Project Interactions

Project interactions that may give rise to impacts to the receptor VCs of human and wildlife health are those activities which release substances (either controlled or fugitive) to various environmental media (intermediate VCs) such as air, soil, water, sediment, groundwater, and food (biological tissues), and ultimately influence the exposure scenarios of the human and ecological receptors. As outlined in Section 5.3.4.2 of Chapter 5, as well as in previous chapters of this Application/EIS, potential effects from Project activities are normally defined through tabulating Project-VC interaction ranking matrices and characterizing those activities/interactions as (I) negligible (warranting no further consideration), (II) potentially adverse (warranting further consideration), or (III) key interactions (warranting further consideration) for assessment of effects (see: Chapter 6; Chapter 11). Because the receptor VCs of human and wildlife health are mediated through contact with intermediate VCs of environmental quality, the human and ecological risk assessment relies on the resultant assessment of other biophysical disciplines (e.g., surface water quality, air quality, soil quality, etc.) to first determine the Project interaction ranking and where warranted consequent media-specific quality. Thereafter, HHERA methods integrate this predicted information into health risk modelling procedures to determine the Project effects to receptor VCs of human and ecological health. Accordingly, the HHERA does not undertake a separate Project-VC interaction ranking matrix, but rather by using the predicted environmental data from the assessed intermediate VC, the HHERA aligns with those Project-VC interaction matrices documented in earlier chapters and inherently assesses those interaction deemed to warrant further assessment. Therefore, it is not necessary to characterize potential Project-VC interactions as I, II, or III for the purpose of this chapter.

22.5.2.2 Discussion of Potential Effects

22.5.2.2.1 Activities Potentially Affecting Air Quality and Health Risk

Particulate matter emissions with adsorbed contaminants are associated with land disturbance, coal handling, hauling, and combustion emissions associated with vehicle traffic and other emission sources

associated with the Project. In addition, regulated air quality parameters can be potentially altered because of combustion gas emissions associated with Project activities (Dillon, 2021).

Community residents, Indigenous peoples, or temporary residents and seasonal land users (hunting/harvesting or recreational land use) spending time within the HHERA LSA may be exposed to chemical constituents associated with fugitive air release from Project activities through direct inhalation.

Since this pathway represents a defined uncontrolled release from the Project, it is of primary importance to the overall quantitative environmental health assessment, and is evaluated further in the human health risk assessment through both direct pathways (i.e., inhalation) and indirect pathways (i.e., soil contact, ingestion of surface water and country foods).

Within the practice of ecological risk assessment, the airborne COPC inhalation pathway is typically not evaluated directly for wildlife because of wide ranging uncertainties concerning receptor inhalation physiology, behaviour and location. In general, other exposure pathways are much more relevant to driving wildlife exposure such as ingestion of water, diet items, and incidental ingestion of soil (CCME, 2020). Inclusion of inhalation exposures may be warranted for certain sites and receptors may experience a high degree of exposure. An example of this may be a burrowing mammal at a site with elevated concentrations of volatile organic compounds in the soil vapour, but this is not applicable to the Project. Importantly, however, COPCs adsorbed to airborne particulates are assessed indirectly through incremental changes to soil quality associated with total particulate deposition and conservation in the soil, and then multimedia transfer via food web (i.e., COPCs transfer from soil to vegetation and uptake by wildlife).

22.5.2.2.2 Activities Potentially Affecting Soil Quality and Health Risk

It is expected that particulate emissions will be associated with land disturbance, coal handling, hauling, and combustion gas emissions associated with vehicle traffic and other emission sources associated with the Project. Chemical constituents associated with Project-derived particulate emissions have the potential to accumulate in soils within the HHERA LSA because of particulate deposition and mixing with surficial soil horizons.

Community residents, Indigenous peoples, or temporary residents and seasonal land users (hunting/harvesting or recreational land use) may be exposed to chemical constituents through direct contact and incidental ingestion of soils. Wildlife may be exposed to chemical constituents through incidental soil ingestion (e.g., incidental ingestion with consumption of vegetation).
Since this pathway represents a defined uncontrolled release from the Project, it is considered to be of primary importance to the overall quantitative environmental health assessment and is evaluated further in the human health and wildlife health risk assessments through the multimedia food web exposure model.

22.5.2.2.3 Activities Potentially Affecting Surface Water Quality and Health Risk

Residual effects to surface water quality, specifically within Alexander Creek which will be a receiver of treatment pond effluent, are predicted because of Project activities (SRK, 2021a). Community residents, Indigenous traditional land users, or temporary residents and seasonal land users (hunting/harvesting or

recreational land use) may be exposed to chemical constituents through direct contact and ingestion of surface water.

Effluent discharge from the Project site is predicted to have a measurable effect on surface water quality and as such this pathway is of primary importance to the overall quantitative environmental risk assessment and is the basis for the aquatic health risk assessment. In addition, predicted changes to surface water quality have been incorporated into the multimedia human health and wildlife health risk assessments.

22.5.2.2.4 Activities Potentially Affecting Sediment Quality and Health Risk

Changes to surface water quality can potentially influence sediment chemistry in receiving waterbodies; however, detectable changes in sediment quality because of changes to air quality and surface water quality are expected to be negligible. Changes to sediment quality are a function of predicted changes to surface water quality, and as such are considered as a secondary pathway.

Community residents, Indigenous traditional land users, or temporary residents and seasonal land users (hunting/harvesting or recreational land use) may be exposed to chemical constituents through direct contact and incidental ingestion of sediments.

Wildlife that rely primarily on aquatic food sources are expected to use local watercourses and waterbodies for foraging and may be exposed to chemical constituents through incidental ingestion of sediment.

22.5.2.2.5 Activities Potentially Affecting Groundwater Quality and Health Risk

According to the groundwater effects assessment (SRK, 2021b), the predicted effect of the Project activities on groundwater quality is not significant. In addition, impacts to groundwater quality are not anticipated to have a measurable impact on water quality where people obtain drinking water.

Impacts to groundwater quality are therefore considered as a secondary (negligible) pathway and are not specifically assessed as part of this HHERA.

22.5.2.2.6 Activities Potentially Affecting Food Quality and Health Risk

Residual effects to soil quality associated with particulate matter deposition and predicted effects to surface water quality have the potential to induce changes in the concentration of chemical constituents in the tissues of plants and animals in the HHERA LSA.

Community residents, Indigenous traditional land users, or temporary residents and seasonal land users (hunting/harvesting or recreational land use) may be exposed to chemical constituents through ingestion of plant and animal tissues within the HHERA LSA. Similarly, wildlife receptors may be exposed to chemical constituents through ingestion of plant and prey items.

Potential changes in food quality are assessed as part of the human health and wildlife health risk assessments using the multimedia food web exposure model developed for this HHERA. Pathways affecting traditional food quality include:

- Uptake and accumulation of Project-related chemical constituents in vegetation (e.g., berries, plants) from soil after incremental changes to soil condition following prolonged air particulate deposition;
- Uptake and accumulation of Project-related chemical constituents in terrestrial feeding wildlife from soil impacts through trophic transfer; and
- Uptake and accumulation of Project-related chemical constituents in aquatic feeding wildlife (including fish) because of changes to surface water quality and trophic transfer.

In light of the collective Project activities and their potential linkages to health risk, as described above, a conceptual exposure model was developed for ecological valued components (Figure 22.5-1) and for human health risk (Figure 22.5-2). These conceptual exposure models provide the basis for subsequent quantitative exposure/risk models for the Project Case and Cumulative Case assessment scenarios discussed in subsequent sections.

Impacts to groundwater quality are therefore considered as a secondary (negligible) pathway and are not specifically assessed as part of this HHERA.

22.5.2.3 Transboundary Effects

Predictive air quality modelling (Chapter 6) determined that the HHERA RSA did not warrant transboundary effects modelling in Alberta or the U.S.A. Predictive water quality modelling (Chapter 11) determined that Lake Koocanusa, which straddles the Canada-U.S.A. border, would experience no significant effects in surface water quality. Accordingly, the human health and ecological risk assessment does not consider transboundary exposure scenarios. As described in Chapter 6, Section 6.5.4.2.1 and Chapter 11, Section 11.5.2.3, air and water quality impacts are not anticipated on federal lands; therefore, the human health and ecological risk assessment does not consider exposure scenarios on federal lands.

22.5.3 Mitigation Measures

The assessment of health risk to ecological receptors and people associated with local land use inherently considers the Project's mitigation measures that are engineered and operationally planned within the Project and reflected in the fate and transport modelling of the air quality modelling (Chapter 6) and the surface water quality modelling (Chapter 11). A wide array of design mitigation measures are therefore directly reflected in the predicted environmental quality for surface water and air, and then secondarily integrated when predicting how these media affect soil, plant/animal tissue (i.e., food) and sediment quality. Therefore, to a large extent, various aspects of the potential linkages between Project activities and health risk to VCs have been mitigated before the health risks are quantified (i.e., health risk predictions are based on the residual effects of the various receptor VCs assessed in other chapters).

Further opportunity to mitigate health risk to individual receptors may be possible through mitigation of exposure, which is an essential component of any toxicological health risk; this would fundamentally mean mitigative measures that either further reduce the exposure point concentration of substances to ecological receptors and people (e.g., use of dust suppression along haul road to decrease fugitive airborne particulate concentrations and dispersion), or through reduction of the frequency/duration by which ecological receptors and people may come into contact with the substances through contact with certain media, such as water, air, and food.

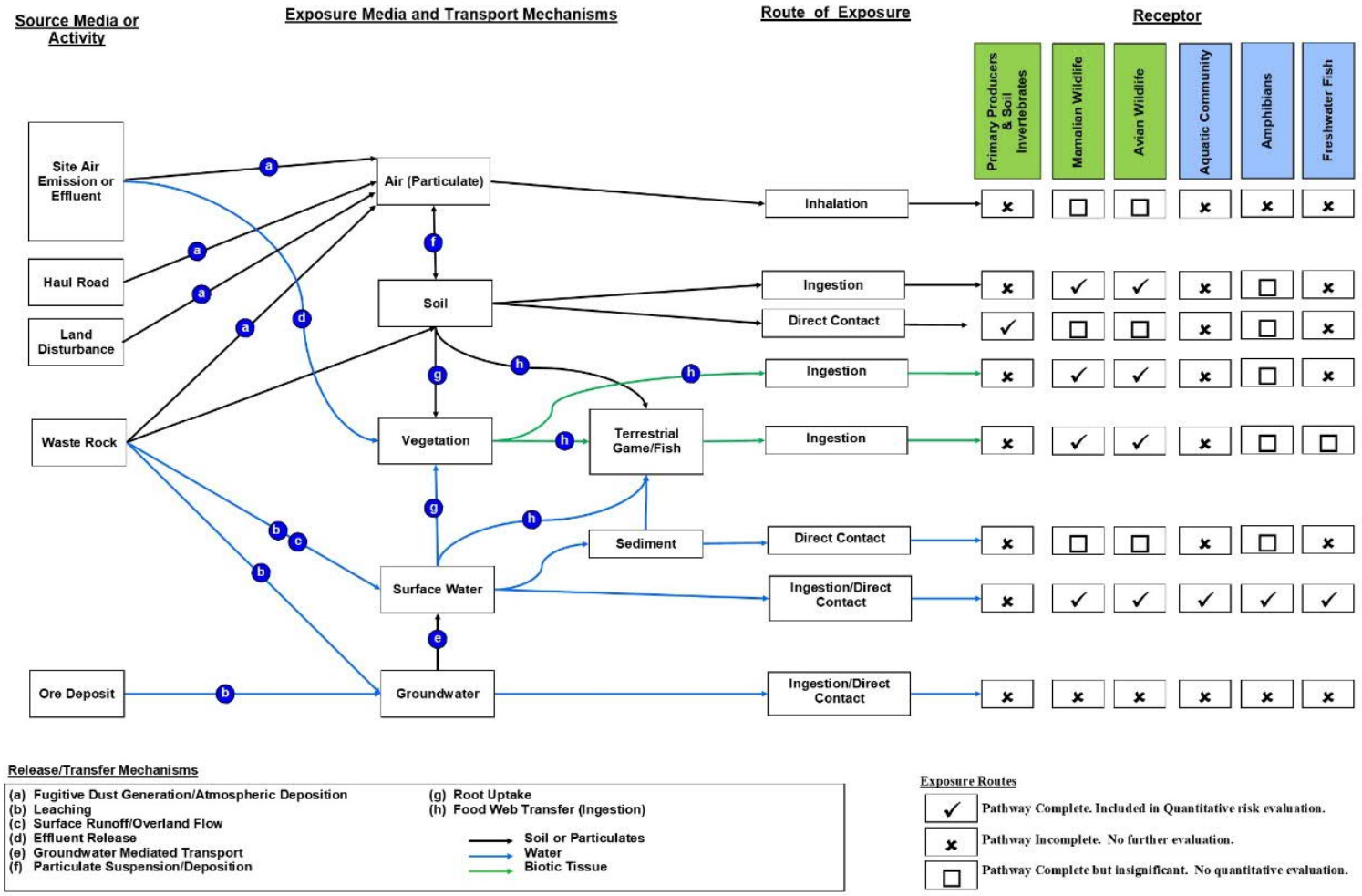

Figure 22.5-1: Conceptual Exposure Model for Ecological Risk Evaluation

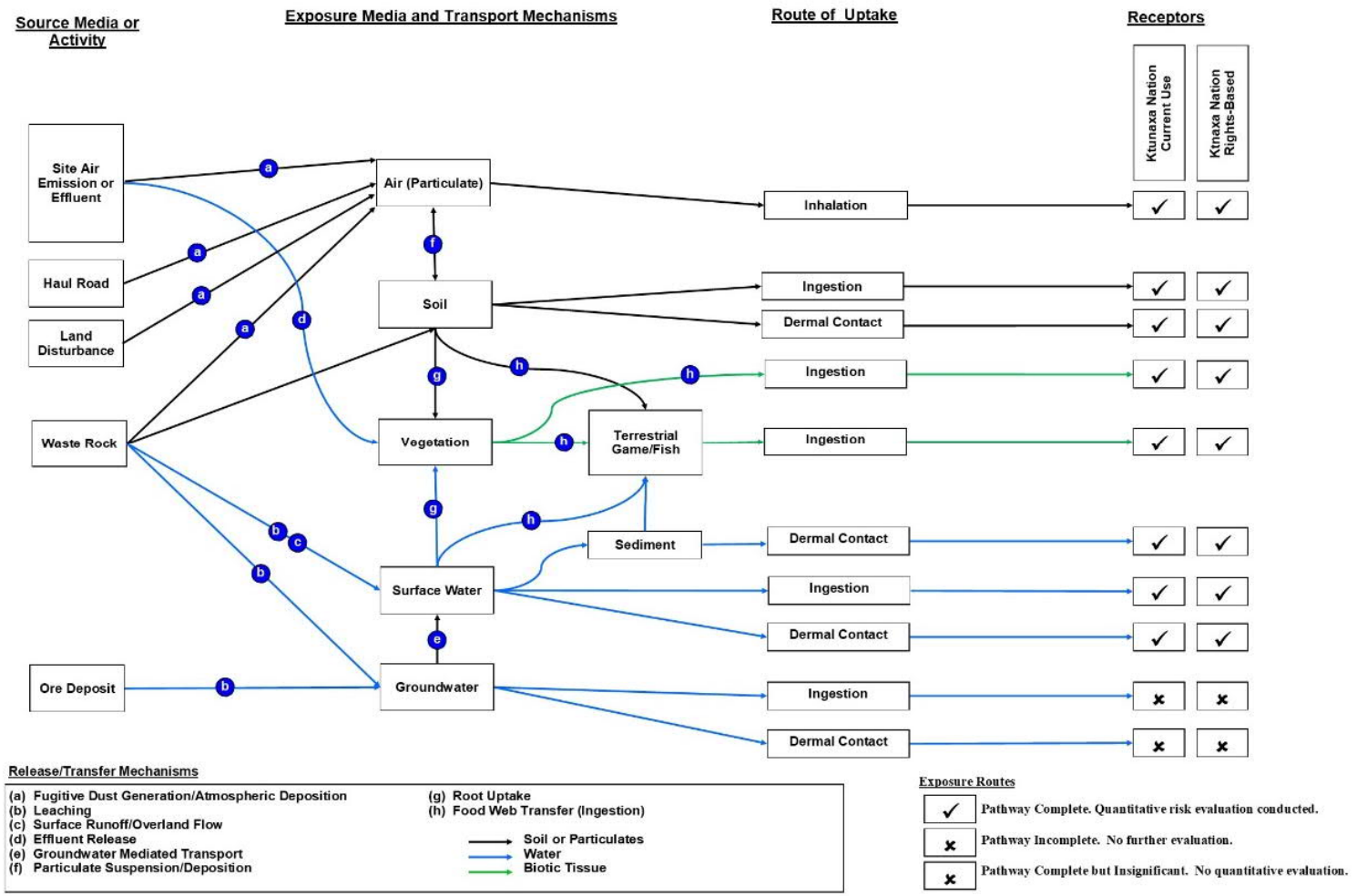

Figure 22.5-2: Conceptual Exposure Model for Human Health Risk Evaluation

The risk assessment scenarios described herein have used conservative exposure assumptions which intentionally err in overestimating, rather than underestimating, health risk. This is the case for both ecological and human health risk, where the receptors (i.e., a wildlife species or local people on the land) are assumed to receive all their exposure at locations on or near the Project continuously throughout their life. It is likely that such scenarios are unlikely and that a degree of "avoidance" (either intentional or unintentional) may mitigate exposure and risk through a reduction of exposure "frequency". In some instances where the mine footprint and major works preclude land use or a receptor's presence during the mine's operational life, institutional mitigative measures such as fencing or operational policies may be invoked until the mine is closed and fully reclaimed in order to mitigate potential exposures and health risk.

22.5.4 Characterization of Residual Effects, Significance, Likelihood and Confidence

22.5.4.1 Assessment Methods

The methods for Project Case effects assessment of ecological and human health risk are fundamentally similar to those executed for the Base Case health risk, wherein exposure point concentrations are used to derive an estimated exposure, and then the estimated rate of exposure to a substance is compared to a reference (threshold) value of exposure that is known to be safe. This comparison of the estimated rate of exposure to a safe rate of exposure is then expressed numerically as a quotient (i.e., hazard quotient), or as a probability in the case of cancer-causing substances. The similar approaches are necessary to enable direct comparison between the Base Case risk estimates and those attributed to the Project Case or Cumulative Case. However, additional methods beyond those of the Base Case are necessary for the Project Case effects assessment, namely prediction of future exposure through predictive fate and transport modelling (performed within the assessment of air quality (Chapter 6) and surface water quality (Chapter 11). The following sections briefly describe the process for the Project Case and Cumulative Case effects assessment of toxicological health risk to terrestrial and aquatic wildlife, and people.

22.5.4.1.1 Exposure Assessment Methods for Terrestrial and Aquatic Feeding Wildlife

Exposure assessment for terrestrial and aquatic feeding wildlife is conducted by calculating average daily dose of contaminants to wildlife receptors because of intake and assimilation into biological organisms through common intake pathways (i.e., ingestion of food, water, sediment, biological tissues, etc.). Average daily dose is calculated following standard multimedia exposure equations (CCME, 2020). Details of the exposure assessment, including receptor specific characteristics of intake rates, food chain dietary preferences, modelling algorithms (GoldSim), and the calculated average daily dose are provided in the technical support document on human health and ecological risk assessment (Appendix 22-A).

Briefly, exposure assessment for terrestrial and aquatic feeding wildlife is executed through the following major steps and assumptions (Table 22.5-1):

1. Establishing predictive equations for transfer of contaminants between abiotic media (e.g., water to sediment, air particulates to soil) to predict future exposure point concentrations of COPCs arising from Project emissions and releases;
2. Establishing predictive equations for transfer of contaminants from environmental abiotic media (e.g., soil, water, sediment, air) to internal tissue of ecological receptors;

3. Establishing predictive equations to simulate transfer of contaminants from prey tissue to predator tissue and to predict average daily dose (intake rate) of COPCs for surrogate receptors;
4. Use of baseline monitoring data to support baseline exposure assessment and for seeding equations in steps 1 to 3 above for the Project Case and Cumulative Case;
5. Use of modelled air quality, water quality and sediment quality data for exposure assessment and seeding equations in steps 1 to 3 above for the Project Case and Cumulative Case; and
6. Integrating toxicity reference values for the contaminants and receptors of concern with their associated exposure metrics to calculate hazard quotients as measurement endpoints of risk.

Table 22.5-1: Project Case - Fundamental Exposure Assessment Approach and Assumptions (AECOM, 2021)

Parameter	Project Case Exposure Assumptions
Soil Quality	Calculated as the sum of the 95th percentile of baseline soil concentration and the predicted incremental soil concentration associated with particulate deposition over the 15-year mine life at each critical receptor location. Particulate deposition was modelled using the total particulate deposition to the ground surface. Critical receptor location specific incremental soil concentration is calculated using United States Environmental Protection Agency (U.S. EPA) methods for estimating incremental soil concentration.
Surface Water Quality	Project case uses the predicted concentrations of substances of interest as predicted by the surface water quality model (SRK, 2021a) rolling average concentration over the annual model duration.
Air Quality	Air quality modelling was conducted using a three-year meteorological time-series dataset and Project activities characteristics of the maximum production period. Exposure point concentrations (deterministic and probabilistic) were generated for each Critical Receptor Location using location-specific 365-day time-series of predicted PM_{10} concentrations and chemical composition associated with individual emission sources.
Sediment Quality	Prospective sediment quality is modelled using water-to-sediment partition coefficients (Kd) as determined from baseline data for each of Upper Alexander Creek, Lower Alexander Creek, and Upper Grave Creek. Sediment concentrations are calculated based on annual average surface water concentration at water quality prediction nodes.
Fish Tissue	Modelled based on maximum 30-day rolling average of critical receptor location specific predicted water quality (SRK, 2021a) and derived water-to-fish concentrations ratios.
Fish Eggs	Modelled based on critical receptor location specific predicted surface water quality and water-to-fish concentration ratios. Selenium concentration predicted as a function of site-specific predicted surface water concentration using the Elk Valley selenium bioaccumulation model.
Shellfish Tissue	Calculated as a function of baseline surface water concentration and literature derives water-to-crustacean concentration ratios.
Large Mammals	Calculated from intake based on area weighted average accounting for overlap between foraging range and the Project footprint. Concentrations calculated using multimedia food web incorporating calculated Project incremental soil quality and feed-to-large mammal transfer factors.

Parameter	Project Case Exposure Assumptions
Small Mammal Tissue	Modelled using critical receptor specific predicted incremental soil concentration and literature derived soil-to-whole organism concentration ratios for temperate small mammals.
Bird Tissue	Modelled using critical receptor specific predicted incremental soil concentration and literature derived soil-to-whole organism concentration ratios for temperate avian receptors.
Bird Eggs	Modelled using critical receptor location specific predicted incremental soil quality and soil-to-bird concentration ratios, except for selenium which is modelled based on receptor location specific predicted surface water quality data using the Elk Valley selenium bioaccumulation model.
Berries	Modelled using critical receptor location specific predicted incremental soil concentration and soil-to-berry concentration ratios.
Plant Roots	Modelled using critical receptor location specific predicted incremental soil concentration and soil-to-shrub concentration ratio.
Other Plants	Modelled using critical receptor location specific predicted incremental soil concentration and soil-to-plant concentration ratios.
Lichens and Mushrooms	Modelled using critical receptor location specific predicted incremental soil concentration and soil-to-mushroom/lichen concentration ratios.

For assessment of Project effects to aquatic health, it was necessary to recognize that certain locations (nodes) of the surface water network reflect Project-related effects and other locations reflect the water quality after confluence with upstream waters influenced by Teck operations, and therefore are considered cumulative assessment conditions. The water quality prediction nodes included in the Water Quality Prediction Model (SRK, 2021a; Appendix 11-E) considered in the current HHERA, with distinction between Project Case versus Cumulative Case, are presented in Table 22.5-2. A detailed description of the selenium bioaccumulation model, including model equations, inputs, and assumptions is provided in Appendix 22-A, Section 3.2.1 and Appendix 22-B, Section 1.0.

Table 22.5-2: Surface Water Quality Prediction Nodes and Assessment Classification

Watershed	Node	Description	Assessment Case
Grave Creek	GC-1	Grave Creek upstream of confluence with Elk River	Cumulative
	GC-2	Grave Creek downstream of confluence with Harmer Creek	Cumulative
	GC-3	Grave Creek upstream of confluence with Harmer Creek	Project
	GC-4	Harmer Creek upstream of confluence with Grave Creek	Cumulative
	GC-5	Grave Creek downstream of GCR withdrawal location	Project
	GC-6	Grave Creek upstream of GCR withdrawal location	Project
	GC-7	Grave Creek downstream of Clean Coal Transfer Area	Project
	GC-8	Grave Creek downstream of CHPP	Project
Alexander Creek	AC-1	Alexander Creek Upstream of Highway 3	Project
	AC-2	Alexander Creek mid-reach (between highway 3 and West Alexander)	Project

Watershed	Node	Description	Assessment Case
	AC-3	Alexander Creek downstream of confluence with West Alexander	Project
	AC-4	Alexander Creek upstream of confluence with West Alexander	Project
	AC-5	West Alexander upstream of confluence with Alexander Creek	Project
	AC-6	West Alexander downstream of confluence with Alexander Creek	Project
Elk River Valley	EV-ER1	Elk River downstream of confluence with Michel Creek	Cumulative

22.5.4.1.2 Exposure Assessment Methods for People

An exposure assessment was conducted for each COPC identified in the problem formulation stage and for each of the human receptors assessed. Exposure estimates were conducted using foodweb and human exposure models developed in GoldSim, and reflect federal exposure and risk assessment principles (Health Canada, 2010b).

Exposure of human receptors is calculated as a function of the concentration of COPCs in environmental media (i.e., soil, water, air, wild food tissues etc.), the frequency and duration of exposure, and the physiological characteristics of the KNC people as representing the maximally exposed individuals in the local study area. Receptor characteristics for current use and rights-based traditional land use receptors used in the quantitative exposure assessment are detailed in the technical support document on human health and ecological risk assessment (Appendix 22-A).

The exposure assessment was conducted using a spatially explicit approach, whereby concentrations of COPCs in environmental media and edible tissues (e.g., vegetation, consumed wildlife, fish etc.) are determined for each of the identified critical receptor locations (CRID 1-15). A description of the methods for estimation of COPC concentration in wild food tissues and estimated concentrations carried forward for quantitative assessment are presented in Appendix 22-A. This approach explicitly acknowledges that the probability of elevated exposure is directly related to the geographic location of KNC peoples' traditional activities and the proximity to Project's related sources of contaminants.

Human exposure models were developed in accordance with methods described by Health Canada (2010b) for each of the current use and rights-based receptors at each of the 15 identified critical receptor locations (i.e., 10 receptors x 15 locations = 150 exposure estimates per COPC). Exposure estimates were calculated as the estimated daily dose (EDD), expressed as milligrams of a chemical absorbed per kilogram of bodyweight per day (mg/kg bw/day). To account for lifetime exposure and facilitate the assessment of carcinogenic risk estimates, lifetime amortized daily dose (LADD) was calculated for current and rights-based composite receptors spanning the entire lifespan in accordance with Health Canada (2010b) methods. Detailed methodology for human exposure models, graphical representation of the multimedia exposure model and the calculated dose estimates are presented in the technical support document on human health and ecological risk assessment (Appendix 22-A).

22.5.4.1.3 Assessment Limitations

The HHERA was conducted in consideration of anticipated Project related releases and quantitative data, where available. Baseline concentrations of contaminants of potential concern were estimated based on

quantitative baseline data using the maximum annual average concentration of respirable dust (PM_{10} = 28 µg/m^3) and chemical composition measured from total particulate samples analyzed as part of the baseline air quality dataset. The baseline air quality dataset does not include concentration data for volatile organic compounds (VOCs) or polycyclic aromatic hydrocarbons (PAHs). The lack of baseline data for VOCs is not considered to present a significant limitation to the current assessment. VOCs were not identified in the air quality assessment as being likely Project activity related contaminants, and it is considered unlikely that Project activities would result in enhanced exposure to VOCs.

The lack of baseline data on PAHs associated with ambient airborne particulates introduces a potential source of uncertainty to the risk estimates for PAHs, in particular for benzo(a)pyrene which was included in the HHERA as a contaminant of potential concern as a result of Health Canada publishing an inhalation specific toxicity reference value. Speciated particulate matter data was predicted in the air quality assessment (Chapter 6) using air dispersion modelling, including diesel particulate matter as well as particulate matter arising from other activities such as road dust and material handling and processing. The speciated particulate matter concentrations were used in the HHERA to quantify the impacts to various receptor pathways based on the individual components of the particulate matter (e.g., benzo[a]pyrene and metals). Diesel particulate matter was not presented in Chapter 6 as there are no limits to compare against. As diesel particulate matter is exclusively anthropogenic and the Project is proposed in a relatively undisturbed area, it is likely that the concentrations of diesel particulate matter in the immediate Project area will primarily result from Project operations. When considered in this context, it is likely that the baseline concentrations of diesel particulate matter are negligible when compared to the Project contributions, and are unlikely to materially affect the findings of the assessment.

The lack of baseline data for benzo(a)pyrene introduces uncertainty in the calculated Lifetime Cancer Risks (ILCR) for the Project and cumulative assessment cases. Calculated ILCRs for benzo(a)pyrene under the Project and cumulative assessment case are likely underestimated to some degree. The additional exposures related to baseline conditions have been conservatively examined by assigning the maximum annual average PM_{10} (28 µg/m^3) to the PAH signature of diesel exhaust. This approach is highly conservative and will overestimate the potential concentration in respirable dust under baseline conditions, as combustion exhaust is the primary source of PAHs associated with ambient airborne particulates. The calculated incremental lifetime cancer risk associated with this degree of exposure is approximately 1×10^{-39} and represents a negligible contribution to the calculated ILCRs for the current and rights-based receptors under either the Project or cumulative assessment cases. This source of uncertainty is therefore considered to be insignificant to the assessment and will not appreciably change the conclusions of the HHERA.

22.5.4.2 Potential Residual Effects Assessment

22.5.4.2.1 Potential Project Effects to Terrestrial Wildlife Health

The overall Project-related risk to wildlife health is considered to be low. Calculated hazard quotients for terrestrial mammalian and avian receptors assessed as part of the HHERA are presented in Table 22.5-3. A brief summary of the potential residual effects for each identified contaminant of potential concern is provided below. The majority of identified contaminants of potential concern have been determined to pose a low and likely negligible risk to terrestrial wildlife heath. Overall Project risks associated with

cadmium exposure to the American Dipper are considered to pose a low risk based on conservative assumptions included in the HHERA.

Table 22.5-3: Calculated HQs for Wildlife Receptors for the Project Case

Receptor	As	Cd	Co	Cr	Se	Tl
American Badger	0.014	0.17	0.32	0.011	0.32	0.029
American Marten	0.19	2**	2.6**	0.11	4.2*	0.3
Bighorn Sheep	0.015	0.023	0.0097	0.018	0.18	0.056
Canada Lynx	0.0000099	0.0083	0.025	0.000066	0.013	0.0000013
Deer Mouse	0.53	4.8**	0.28	0.13	12*	0.41
Elk	0.0027	0.0041	0.0017	0.0033	0.033	0.01
Grizzly Bear	0.00046	0.0031	0.0003	0.00027	0.074	0.0017
Least Chipmunk	0.21	1.3**	0.3	0.13	3.5*	0.39
Little Brown Myotis	0.21	2.1**	0.04	0.023	5*	0.083
Masked Shrew	7.9*	58**	7.7**	3.5*	140*	10*
Moose	0.0014	0.0018	0.0009	0.0017	0.12	0.019
Northern River Otter	0.0011	0.05	0.006	0.001	7.4**	0.068
Snowshoe Hare	0.1	0.12	0.3	0.13	0.58	0.36
American Dipper	0.086	6.6**	2.1**	0.36	Aquatic	0.087
Canada Goose	0.047	0.031	0.49	0.12	2.7**	0.041
Common Merganser	0.0077	0.037	0.027	0.0062	Aquatic	0.043
Common Raven	0.076	0.76	0.62	0.06	1.7*	0.0084
Mallard	0.033	0.38	0.39	0.092	Aquatic	0.047
Northern Goshawk	0.00023	0.22	1.2**	0.003	Aquatic	0.0000017
White-tailed Ptarmigan	0.064	0.48	0.18	0.072	1.2*	0.01

Notes:
Shaded values indicated HQs in exceedance of HQ=1.0
Shaded cells indicate calculated hazard quotients greater than threshold of HQ=1.0
* Calculated hazard quotient not appreciably different from Base Case conditions
** Calculated hazard quotient appreciably elevated relative to Base Case condition. Result is suggestive of potential effect to VC.
Aquatic – Risks to aquatic waterbirds as a result of selenium exposure are considered in the aquatic wildlife health assessment. See Section 22.5.4.2.2

- Arsenic
  - The overall Project related wildlife health risk associated with arsenic exposure is considered to be low and likely negligible.
    - Calculated HQs are below target thresholds for all mammalian and avian ROCs at all critical receptor locations with the exception of the masked shrew.
    - Maximum calculated HQ for the masked shrew is unchanged from Baseline in the Project case. Calculated risk estimates are driven by baseline conditions and are not indicative of a Project-related risk.

- Cadmium
  - The overall Project-related wildlife health risk associated with cadmium exposure is considered to be low and likely negligible for mammalian receptors.
    - Calculated HQs exceed threshold benchmarks for American marten (Max. HQ=2.0), deer mouse (Max. HQ=4.8), least chipmunk (Max. HQ=1.3), little brown bat (Max. HQ=2.1), masked shrew (Max. HQ=58), and American Dipper (Max. HQ=6.6).
    - Cadmium risk to mammalian wildlife is geographically limited to locations within the Project footprint and along mine infrastructure. These locations are not considered to be valued habitat capable of supporting ecological receptors after Project development. Calculated HQs for areas of ecological habitat are below target thresholds, indicating negligible risk.
  - Overall Project related risks are considered to be low for avian receptors.
    - Calculated HQs exceed threshold benchmarks American Dipper (Max. HQ=6.6). Calculated HQs suggest moderate potential magnitude of effect.
    - Calculated HQs for American Dipper exceed target thresholds at locations along Alexander Creek, downstream of the confluence with West Alexander Creek, indicating a low to moderate magnitude of effect associated with the Project-related changes to surface water quality.
    - American Dipper is the only waterbird calculated to exceed target thresholds. The TRV used is a conservative no-observed adverse effects level (NOAEL) that may overestimate risks to the American Dipper relative to identified protection goals for this apparently stable population.
- Cobalt
  - The overall Project-related wildlife health risk associated with cobalt exposure is considered to be low and likely negligible for mammalian and avian receptors.
  - Calculated HQs exceed threshold benchmarks for American marten (Max. HQ=3), masked shrew (Max. HQ=8), Northern Goshawk (Max. HQ=1.2), and American Dipper (Max. HQ=2.1).
  - Calculated HQs suggest low potential magnitude of effect, with the exception of a moderate potential magnitude of effect for the masked shrew. Cobalt risks to mammalian wildlife are geographically limited to locations within the Project footprint and along mine infrastructure (i.e., the haul roads). Calculated HQs for areas of ecological habitat (i.e., not located within roadways) are below target thresholds indicating negligible risk.
  - Calculated HQs marginally exceed threshold benchmarks for Northern Goshawk and American Dipper. Calculated HQs suggest low potential magnitude of effect. In consideration of the conservatism of the assessment and the limited geographic extent of predicted impact, the overall Project risks are considered to be negligible for avian receptors' exposure to cobalt.
- Chromium
  - The overall Project related wildlife health risk associated with chromium is considered to be low and likely negligible.
    - Calculated HQs are below target thresholds for all mammalian and avian ROCs at all critical receptor locations with the exception of the masked shrew.
    - Calculated HQs for the masked shrew are exceed target thresholds in the Base Case. Calculated HQs show negligible change (<1%) from the Base Case. Calculated risk estimates are driven by baseline conditions and are not indicative of a Project-related risk.

    - All calculated HQs for avian receptors were below target thresholds indicating negligible risk.
- Selenium
    - The overall Project related wildlife health risk associated with selenium are considered to be low and likely negligible for terrestrial mammalian and avian receptors.
        - Calculated HQs for terrestrial mammalian receptors exceed target thresholds for a variety of ROCs; however, HQs were generally unchanged relative to the Base Case. Calculated HQs for terrestrial mammalian receptors are driven by baseline conditions and are not indicative of a Project-related risk.
        - Calculated HQs for northern river otter exceeded target thresholds critical receptor locations in areas of direct Project influence (i.e., on haul roads) and are not representative of valued ecological habitat that would support these receptors in the future.
    - Calculated HQs for terrestrial avian receptors (e.g., Common Raven and White-tailed Ptarmigan) were unchanged relative to the Base Case. Calculated HQs for terrestrial avian receptors are driven by baseline conditions and are not indicative of a Project-related risk.
    - Calculated HQs for the Canada Goose are predicted to exceed target thresholds.
        - Predicted HQs in exceedance of the target threshold for the Canada Goose are limited to locations along Lower Grave Creek, and in direct proximity to the Project footprint or mine related infrastructure.
        - These locations are not considered to be valued habitat which would support ecological receptors either now or in the future after Project development. HQs for areas of ecological habitat (i.e., not located within roadways) were below target thresholds.
- Thallium
    - The overall Project related risk associated with thallium exposure is considered to be low and likely negligible for mammalian receptors and negligible for avian receptors.
        - Calculated HQs are below target thresholds for all mammalian and avian ROCs at all critical receptor locations with the exception of the masked shrew.
        - Calculated HQs for the masked shrew are unchanged (<1%) relative to the Base Case. Calculated risk estimates are driven by baseline conditions and are not indicative of a Project-related risk.
        - All calculated HQs for avian receptors were below target thresholds.

22.5.4.2.2 Potential Project Effects to Aquatic Wildlife Health

As described in Chapter 12, fish bearing reaches within the Fish and Fish Habitat LSA are populated by Westslope Cutthroat Trout, Bull Trout, Mountain Whitefish, and Eastern Brook Trout. The U.S. EPA (2016) derived fish egg selenium benchmark of 15.1 mg/kg dw is considered protective of the fish species present in the Fish and Fish Habitat LSA based on the following rationale (refer to Appendix 22-B, Section 2.2.4 for additional details):

- The U.S. EPA fish-egg selenium benchmark directly considers the cutthroat trout Oncorhynchus genus in its derivation;
- The U.S. EPA benchmark considers the Salvelinus genus, which includes both Bull Trout and Eastern Brook Trout (non-native species);
- The freshwater whitefish genus Prosopium, which includes Mountain Whitefish, is not directly considered in the U.S. EPA derivation; however, a secondary study included in the benchmark

derivation for the EVWQP assessed potential effects to mountain whitefish and identified a no effect concentration of 32.5 mg/kg dw for the larval deformity endpoint, and 33.2 mg/kg dw for survival;

- Burbot have not been documented in the Fish and Fish Habitat LSA, but are present in the Aquatic RSA in Lake Koocanusa in low densities. The Lake Koocanusa and Kootenai River selenium standard for fish eggs/ovaries as of December 25, 2020 is the same as the U.S. EPA benchmark of 15.1 mg/kg dw (Montana Legislative Services Division, 2022); and
- Selenium is an important physiologically regulated micronutrient that has been shown to have a steep species sensitivity distribution, with many species exhibiting a threshold of effects occurring around the 20 mg/kg dw concentration range.

Given that the U.S. EPA fish egg selenium benchmark of 15.1 mg/kg dw is considered protective of the fish species present in both the Fish and Fish Habitat LSA and Aquatic RSA, use of this benchmark as a proxy for all sensitive life stages of all fish species known to bioaccumulate selenium in the vicinity of the Project is appropriate.

Potential risk to fish populations in the Fish and Fish Habitat LSA as a result of selenium bioaccumulation was assessed by calculating predicted fish egg selenium concentration ([Se]egg; mg/kg dw) using the three-step Elk Valley selenium bioaccumulation model and predicted aqueous selenium concentrations from the Project water quality model for the median (50th percentile; P50) and 95th percentile (P95) source term input scenarios assuming the Mine Rock Storage Facility layering approach is successful. Details on the three-step model, including model equations, inputs, and assumptions are provided in the Supplementary Assessment of Selenium Bioaccumulation Risk to Fish (AECOM, 2023; Appendix 22-B). Predicted concentration of total selenium in water ([Se]aq; µg/L), and the associated predicted concentration of selenium in fish egg ([Se]egg; mg/kg dw), based on the three-step bioaccumulation model, are presented in Table 22.5-4.

Table 22.5-4: Predicted Concentrations of Selenium in Surface Water ([Se]aq; µg/L) and Fish Eggs ([Se]egg; mg/kg dw) at Water Quality Model Assessment Nodes

Assessment Node	[Se]aq		[Se]egg	
	P50	P95	P50	P95
GC-1	17.79	24.09	12.08	13.04
GC-2	22.21	29.98	12.78	13.78
GC-3	0.85	1.52	10.95	10.96
GC-4	35.35	47.50	14.36	15.47
GC-5	0.85	1.52	10.95	10.96
GC-6	0.85	1.51	10.95	10.96
GC-7	0.87	1.55	10.96	10.96
GC-8	0.85	1.51	10.95	10.96
AC-1	1.19	2.21	10.96	10.97
AC-2	1.24	2.31	10.96	10.97
AC-3	1.57	2.99	10.96	10.98
AC-4	0.85	1.51	10.95	10.96

Assessment Node	[Se]aq		[Se]egg	
	P50	P95	P50	P95
AC-6	4.79	9.56	10.98	10.99
EV_ER1	8.44	8.79	10.99	10.99

Notes: Bold values indicate exceedance of 15.1 (mg/kg dw), the most stringent fish egg concentration benchmark identified.

Predicted fish egg selenium concentrations were compared to the U.S. EPA (2016) benchmark of 15.1 mg/kg dw. Concentrations of selenium in fish eggs at AC-3 (located immediately downstream of the confluence with West Alexander Creek), are predicted to increase from 10.95 to 10.96 mg/kg dw under the 50th percentile source term scenario, and from 10.96 to 10.98 mg/kg dw under the 95th percentile source term model scenario relative to the upstream reference condition (AC-4). Concentrations of selenium in fish eggs at AC-6 (West Alexander Creek downstream of the Main Sediment Pond) are predicted to be 10.98 mg/kg dw under the 50th percentile source term scenario, and 10.99 mg/kg dw under the 95th percentile source term model scenario. Predicted concentrations of selenium in fish eggs at model nodes along West Alexander Creek and Alexander Creek show a very slight increase as a result of the Project; however, predicted concentrations are below the identified tissue-based toxicity reference value of 15.1 mg/kg dw protective of local fish populations. Potential effects to fish reproduction in West Alexander Creek and Alexander Creek are therefore considered to be negligible.

Water quality nodes impacted by discharge from Harmer Creek exhibit an elevated predicted concentration of selenium in fish eggs. None of the predicted fish egg concentrations of selenium in Grave Creek downstream of the confluence with Harmer Creek exceed the fish egg concentration benchmark of 15.1 mg/kg dw. Predicted fish egg concentrations in Harmer Creek (upstream of the confluence with Grave Creek and impacted solely by activities at Teck's Elkview Operations) are predicted to marginally exceed the U.S. EPA egg selenium benchmark of 15.1 mg/kg dw but are below the egg selenium benchmark of 18 mg/kg dw derived in support of the Area Based Management Plan (Teck, 2014a).

Predicted fish tissue concentrations are not directly comparable to baseline tissue concentrations presented in Appendix 12-D because the EVWQP Elk Valley bioaccumulation model predicts concentrations of selenium in fish eggs, whereas the baseline sampling entailed non-lethal tissue sampling of muscle plugs. As described in Table 22.4-1, baseline fish tissues for potentially affected stream reaches were modelled based on derived concentration ratios in conjunction with measured baseline water quality data. Although conversion factors from egg to muscle tissue concentrations exist in the literature, comparing modelled egg concentrations to measured muscle concentrations would introduce a high level of uncertainty to the assessment. For baseline aquatic wildlife heath risk estimates, please refer to Section 22.4.2.2.2.

Overall, the proposed Project and associated activities are considered to present a low risk to aquatic health. Calculated hazard quotients for aquatic receptors assessed are presented in Table 22.5-5 and Table 22.5-6 for surface water and sediment exposures respectively. Risk estimates in exceedance of target thresholds at Project assessment nodes were generally limited to the lower reaches of West Alexander Creek and immediately after the confluence with Alexander Creek for the aquatic community VC only. The limited geographic extent of the predicted risk estimates, the low to moderate potential magnitude of effect, and the conservative nature of the aquatic risk assessment suggest that overall risks

are low despite predicted changes to surface water quality at Project assessment nodes. A summary of the potential residual effects to aquatic wildlife health is presented below.

Table 22.5-5: Calculated Hazard Quotients for Aquatic Receptor VCs Associated with Surface Water for Project Only Assessment Nodes

		Aquatic Community			Amphibians			Sensitive Fish Species			Waterbird
		Cd	Co	Se	Cd	Co	Se	Cd	Co	Se	Se
Assessment Node	AC_1	0.08	0.8	0.44	0.04	0.01	0.17	0.05	0.01	0.12	0.01
	AC_2	0.09	0.92	0.46	0.05	0.01	0.18	0.06	0.01	0.12	0.01
	AC_3	0.15	1.7**	0.6	0.08	0.02	0.23	0.1	0.01	0.16	0.01
	AC_4	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	AC_5	0.73	9.4**	1.93**	0.4	0.11	0.74	0.48	0.06	0.51	0.05
	AC_6	0.73	9.4**	1.91**	0.4	0.11	0.74	0.48	0.06	0.5	0.05
	GC_3	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	GC_5	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	GC_6	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	GC_7	0.02	0.01	0.31	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	GC_8	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01

Notes:
Calculated hazard quotients presented for those assessment nodes where Project interactions are determined to have a potential effect.
Shaded cells indicate calculated hazard quotients greater than threshold of HQ=1.0.
** Calculated hazard quotient appreciably elevated relative to Base Case condition. Result is suggestive of potential effect to VC.

Table 22.5-6: Calculated Hazard Quotients for Aquatic Community VC Associated with Sediment Contact for Project Only Assessment Nodes

Assessment Node	Aquatic Community (Benthic Invertebrates)		
	Cd	Co	Se
AC_1	0.3	0.1	0.7
AC_2	0.3	0.1	0.8
AC_3	0.5	0.1	1
AC_4	0.1	0	0.5
AC_5	2.7**	0.8	3.2**
AC_6	2.7**	0.8	3.1**
GC_3	0.1	0	0.5
GC_5	0.1	0	0.5
GC_6	0.1	0	0.5
GC_7	0.1	0	0.5
GC_8	0.1	0	0.5

Notes:
Calculated hazard quotients presented for those assessment nodes where Project interactions are determined to have a potential effect.
Shaded cells indicate calculated hazard quotients greater than threshold of HQ=1.0.
** Calculated hazard quotient appreciably elevated relative to Base Case condition. Result is suggestive of potential effect to VC.

- Cadmium
  - Risk estimates in exceedance of target threshold are calculated for benthic invertebrates associated with direct sediment contact.
  - Risk estimates in exceedance of target thresholds are limited to the lower reach of West Alexander Creek before the confluence of Alexander Creek. Maximum calculated HQ is 2.7, suggestive of a low magnitude of effect.
- Cobalt
  - HQs associated with surface water direct contact in exceedance of target thresholds were calculated for assessment nodes AC-3, AC-5 and AC-6. Maximum surface water HQs (HQ=9.4) were calculated for assessment nodes AC-5 and AC-6, located in West Alexander Creek, prior to the confluence with Alexander Creek.
  - The calculated HQs is suggestive of a moderate potential magnitude of effect in the lower reach of West Alexander Creek.
  - Calculated HQ in Alexander Creek at AC-3 immediately after the confluence with West Alexander Creek (HQ=1.7) is suggestive of a low potential magnitude of effect. Calculated HQs quickly decrease below target thresholds downstream.
- Selenium
  - Risk estimates in exceedance of target threshold are calculated for benthic invertebrates associated with direct sediment contact as well as aquatic invertebrates associated with direct contact with surface water.
  - Risk estimates in exceedance of target thresholds are limited to the lower reach of West Alexander Creek before the confluence of Alexander Creek.

Maximum calculated HQs are 1.9 and 3.2 for surface water and sediment exposure, respectively. The calculated HQs are suggestive of a low potential magnitude of effect. Potential Project Effects to Human Health

22.5.4.2.3 Potential Project Effects to Human Health

The overall Project-related risk to human health is considered to be low. Calculated hazard quotients and incremental lifetime cancer risks for human receptors are presented in Table 22.5-7 and Table 22.5-8, respectively.

Table 22.5-7: Calculated HQs for Human Receptors at Critical Receptors Locations under the Project Case

Critical Receptor Location	Arsenic	Cadmium	Cobalt	Chromium	Nickel	Selenium
CRID#1	0.0017	0.702	1.25*	1.69*	0.656	0.00772
CRID#2	0.0025	1.02*	1.27*	1.73*	0.701	0.0399**
CRID#3	0.0024	0.93	1.24*	1.73*	0.679	0.0253**
CRID#4	0.0023	1.08*	3**	1.76*	0.673	0.0205**
CRID#5	0.0025	1.03*	1.29*	1.73*	0.669	0.00593
CRID#6	0.0022	0.809	1.16*	1.75*	0.65	0.00191
CRID#7	0.0022	0.806	1.18*	1.75*	0.65	0.00188
CRID#8	0.0022	0.805	1.18*	1.75*	0.65	0.00188**
CRID#9	0.0022	0.814	1.32*	1.75*	0.65	0.00188**
CRID#10	0.0027**	1.85**	5.7**	1.75*	1.38**	0.00306**

Critical Receptor Location	Arsenic	Cadmium	Cobalt	Chromium	Nickel	Selenium
CRID#11	0.0024	1.25**	2.98**	1.75*	0.991**	0.00244**
CRID#12	0.0022	1.88**	21.3**	1.8*	0.65	0.00188
CRID#13	0.0017	0.702	1.25*	1.69*	0.656	0.00772
CRID#14	0.0024	1.33**	3.34**	1.75*	1.04**	0.00252**
CRID#15	0.0051**	8.15**	33.3**	1.9*	5.26**	0.00838**

Notes:
Shaded values indicated HQs in exceedance of HQ=1
Hazard quotients presented represent maximum calculated hazard quotient of the various human receptors assessed for each critical receptor location. Maximally exposed individuals are associated with the rights-based use scenario.
* Calculated hazard quotient not appreciably different from Base Case conditions.
** Calculated hazard quotient appreciably elevated relative to Base Case condition. Result is suggestive of potential effect to VC.

Table 22.5-8: Calculated ILCR for Human Receptors at Critical Receptors Locations under the Project Case

Critical Receptor Location	Arsenic	Cadmium	Chromium	Nickel	Benzo[a]pyrene
CRID #1	4.8E-4*	2.6E-6	7.1E-6	1.1E-6	6.3E-8**
CRID #2	8.9E-4*	1.8E-4**	1.2E-4**	5.7E-6	6.3E-8**
CRID #3	8.2E-4*	7.6E-5**	5.7E-5**	3.0E-6	6.3E-8**
CRID #4	8.1E-4*	3.9E-4**	2.7E-4**	1.1E-5**	6.4E-8**
CRID #5	8.6E-4*	4.0E-5**	3.2E-5*	2.1E-6	7.5E-9
CRID #6	7.3E-4*	6.0E-6	9.3E-6	1.2E-6	6.3E-8**
CRID #7	7.3E-4*	6.3E-6	9.1E-6	1.1E-6	6.3E-8**
CRID #8	7.2E-4*	3.6E-6	7.1E-6	1.1E-6	6.3E-8**
CRID #9	7.2E-4*	1.1E-5**	9.2E-6	1.1E-6	6.3E-8**
CRID #10	9.7E-4**	1.2E-5**	9.6E-6	1.2E-6	6.3E-8**
CRID #11	8.4E-4*	1.7E-6	6.5E-6	1.1E-6	6.3E-8**
CRID #12	7.3E-4*	1.2E-4**	5.1E-5**	1.9E-6	6.3E-8**
CRID #13	4.8E-4*	2.5E-6	7.1E-6	1.1E-6	6.3E-8**
CRID #14	8.6E-4*	2.6E-6	6.8E-6	1.1E-6	6.3E-8**
CRID #15	2.1E-3**	4.0E-3**	1.0E-3**	4.5E-5**	7.8E-8**

Notes:
Shaded values indicated ILCRs in exceedance of 1:100,000
ILCRs presented are maximum composite ILCRs of the various human receptors assessed for each critical receptor location. Maximally exposed individuals are associated with the rights-based use scenario.
* Calculated hazard quotient not appreciably different from Base Case conditions.
** Calculated hazard quotient appreciably elevated relative to Base Case condition. Result is suggestive of potential effect to VC.

The quantitative human health risk assessment was conducted in consideration of current use and rights-based use Indigenous traditional lifestyle scenarios. Indigenous communities represent the maximally exposed receptor, and as such risk estimates calculated for Indigenous receptors are sufficiently conservative to infer maximal potential risk to non-Indigenous peoples also frequenting the HHERA LSA.

Overall determination of risk is based on maximum calculated risk indices of the various human receptors assessed for each critical receptor location, with the exception of critical receptor location #15. The geographic location of CRID-15 is within the Project exclusion zone, at the location of a planned mine rock repository. This location will cease to function as a human receptor location capable of sustaining a traditional lifestyle until after mine reclamation. Similarly, critical receptor location CRID-12 is situated within the Project footprint and will not be suitable for human occupancy in line with the exposure

scenarios assessed until after reclamation. Risk estimates from these locations are included in the tabulated results below for completeness.

A brief summary of the potential residual effects for each identified contaminant of potential concern is provided below. The majority of identified contaminants of potential concern have been determined to pose a negligible or low and likely negligible risk human health. Overall Project risks associated with cadmium, chromium, and cobalt exposure are considered to pose a low risk.

- Arsenic
  - Calculated hazard quotients for exposure to arsenic to current use and rights-based use receptors were below target thresholds (HQ<1.0). Threshold non-cancer human health risks associated with arsenic exposure are therefore considered to be negligible.
  - ILCRs for the current use and rights-based use human receptors exceeded the target threshold of 1E-05 at all critical receptor locations.
    - The elevated cancer risks are driven primarily by Base Case soil condition and modelled concentration of arsenic in edible fish and mushroom species. Predicted concentration of arsenic in fungi are considered to have a high degree of uncertainty.
    - Predicted ILCRs at all critical receptor locations are reported to have a small (<10%) increase relative to the Base Case assessment for the high consuming rights-based use receptor.
    - Considering the uncertainty in the assessment, the conservatism of the toxicity reference value, and the relatively small incremental change from the Base Case assessment, the overall Project related cancer risk associated with arsenic exposure is considered to be low and likely negligible.
- Cadmium
  - Project related risk from threshold effects associated with cadmium exposure is considered to be low.
    - For threshold effects, calculated HQs for the current use and rights-based use human receptors exceeded the target threshold at seven single critical receptor locations.
    - The maximum calculated HQ (1.9) is for the rights-based toddler at CRID-12, indicative of a magnitude of risk (i.e., 1.0 < HQ ≤ 5).
    - Critical receptor locations along Alexander Creek, downstream of proposed activities have calculated HQs ranging from 1.3 to 1.8.
  - Calculated ILCRs for the current use and rights-based use human receptors exceeded the target threshold of 1E-05 at 7 of 14 critical receptor locations outside the Project exclusion area, with a high magnitude of risk (i.e., ILCR >1E-04).
    - Critical receptor locations with unacceptable ILCRs are primarily confined to critical receptor locations located in the immediate vicinity of mine related infrastructure, such as the haul road and rail loadout.
    - It is considered implausible that these locations would be used in a way that reflects the exposure scenario assessed (i.e., full time, year-round occupancy for the duration of the Project lifecycle).
    - Considering the above information, and the conservatism of the assessment, and uncertainties associated with toxicity data the overall Project-related cancer risk associated with inhalation exposure to cadmium is considered to be low and likely negligible.

- Chromium
  - For threshold non-cancer effects, the overall Project risk associated with chromium exposure is considered to be low and likely negligible.
    - For threshold effects, calculated HQs for the current use and rights-based use human receptors exceeded the target threshold at all locations assessed.
    - Calculated HQs are essentially unchanged relative to the Base Case assessment. Calculated risk estimates are primarily driven by Base Case conditions and are not indicative of a Project-related risk.
    - Uncertainty and conservative assumptions in the modelled surface water quality, as well as conservatism in the TRV used in the present assessment, likely overestimate threshold non-cancer health risks associated with oral exposure.
  - Calculated ILCRs for the current use and rights-based use human receptors exceeded the target threshold of 1E-05 at 5 of 14 critical receptor locations outside the Project exclusion area, with a high magnitude of risk (i.e., ILCR >1E-04).
    - Critical receptor locations with unacceptable ILCRs are primarily confined to critical receptor locations located in the immediate vicinity of mine related infrastructure, such as the haul road and rail loadout.
    - It is considered implausible that these locations would be used in a way that reflects the exposure scenario assessed (i.e., full time, year-round occupancy for the duration of the Project lifecycle).
    - Considering the above information, and the conservatism of the assessment, the overall Project related cancer risk associated with inhalation exposure to chromium is considered to be low.
- Cobalt
  - The overall Project related threshold risk associated with cobalt exposure is considered to be low for current use and rights-based use receptors.
    - Calculated HQs for the current use and rights-based use human receptors exceeded the target threshold at all locations assessed.
    - Calculated HQs are essentially unchanged relative to the Base Case assessment at all but five critical receptor locations.
    - Of critical receptor locations not immediately influenced by physical mine works, incremental change in calculated HQs is limited to locations immediately downstream of the confluence of West Alexander Creek and Alexander Creek.
    - The HQs which indicate an incremental change in calculated HQ and which are exceeding target thresholds are limited to locations directly influenced by physical works (CRID-4 and CRID12) and three critical receptor locations (CRID-10, -11 & -14) which are downstream but in close proximity to the confluence between West Alexander Creek and Alexander Creek.
    - The maximum calculated HQ in Alexander Creek (HQ=5.7) is predicted at CRID-10, located immediately downstream of the confluence with West Alexander Creek.
- Nickel
  - The overall Project related threshold risk associated with nickel exposure is considered to be low and likely negligible.
    - For threshold effects, calculated HQs for the current use and rights-based use human receptors exceeded the target threshold at one location within Alexander Creek, located

immediately downstream of the confluence of West Alexander Creek and Alexander Creek.
    - Uncertainty and conservative assumptions in the modelled surface water quality, as well as conservatism in the TRV used in the present assessment, likely overestimate threshold non-cancer health risks associated with oral exposure to nickel.
  - The overall Project related cancer risk associated with inhalation exposure to nickel is considered to be low and likely negligible.
    - Calculated ILCRs for the current and rights-based human receptors exceeded the target threshold of 1E-05 at a single location (CRID-4) located at the rail loadout, with a low magnitude of risk (1E-5 < ILCR ≤ 5E-5). However, it is considered implausible that CRID-4 would be used in a way that reflects the exposure scenario assessed (i.e., full time, year round occupancy for the duration of the Project lifecycle).
- Selenium
  - Calculated hazard quotients for exposure to selenium to current use and rights-based use receptors were below target thresholds (HQ<1.0). The overall Project-related human health risk associated with selenium exposure is considered to be negligible.
- Benz(a)pyrene
  - Benzo(a)pyrene was assessed as a non-threshold inhalation carcinogen only. Calculated ILCRs for exposure to benzo(a)pyrene to current use and rights-based use receptors were below target thresholds (ILCR < 1E-05) The overall Project-related non-threshold cancer human health risks associated with benzo(a)pyrene inhalation exposure is therefore considered to be negligible.

22.5.4.3 Characterization of Residual Effects

22.5.4.3.1 Terrestrial Wildlife Health

The residual Project effects to terrestrial wildlife health due to the Project activities during Operations, and by inference to other Project phases (Construction and Pre-Production, Reclamation and Closure, Post-Closure), are as follows:

- Duration: Long-term, the predicted non-significant residual effects that are more notable to specific species with small ranges (e.g., masked shrew) are only associated with conditions within the mine footprint or close to the haul road during mine operation and until reclamation is completed.
- Magnitude: Low to negligible, for most substances of interest and locations of interest, there is no discernible change from the Base Case in health risk to populations of terrestrial wildlife. For isolated locations, VC individuals and substances, health risk is considered low to moderate in the mine footprint or haul road, but low in the context of the VC population.
- Geographic Extent: Local to discrete, potential effects to are restricted to the HHERA LSA and largely to the mine footprint or haul road and are inferred to be non-detectable in the HHERA RSA.
- Frequency: Continuous, the potential for low to negligible health risk to terrestrial wildlife is most plausible during the operational lifetime of the mine as represented by the Operations phase; similar but with less exposure/risk are plausible during other phases of the Project.
- Reversibility: Reversible long-term, it is anticipated that low risk magnitude to terrestrial wildlife health will be diminished (mitigated) and in many cases negated once the Project is reclaimed.
- Context: Neutral, the sensitivity and resilience of the terrestrial wildlife health to the low magnitude of risk is considered neutral because the low exposures/risk are unlikely to adversely perturb local

populations. An exception to this may be for non-ranging species (e.g., masked shrew) in key locations such as the mine footprint or haul road; however, the physical disruption to these areas is likely to preclude their presence and therefore preclude exposure to the substances of interest at these locations until such time that reclamation restores physical habitat and acceptable exposure/risk.

Determination of Significance

The residual effects of mine operations activities (and by inference other less influential Project phases) to terrestrial wildlife health are considered not significant. The risk estimates and their magnitude inherently consider operational activities, emissions, and other contaminant releases intrinsic to the predictive modelling of water quality, air quality and secondarily food via transport, fate and food chain modelling. The magnitude of health risk across all terrestrial VCs considered herein was either negligible, low (and likely to be negligible due to conservatism of the assessment), or in isolated instances (e.g., masked shrew) moderate to high but not ecologically significant due to geographic locations of the exposure scenario within the mine footprint or adjacent to the mine haul road. Given the latter cases will be mitigated and/or reclaimed following mine closure (i.e., reversible), the geographically isolated nature, lack of population significance, and its temporal (not permanent), the Project-related risk to terrestrial health is considered not significant. Consequently, the residual effects of the Project on terrestrial wildlife health during all Project phases are considered not significant.

Likelihood and Confidence

Effects from Project activities that are determined to be not significant, as in the present case, do not warrant a characterization of likelihood.

Confidence respecting the conclusion of effect (terrestrial wildlife health risk) being not significant considers the reliability of data and analytical methods used in the assessment of effects. The confidence level ascribed to terrestrial wildlife health risk is moderate. The confidence level derives from consideration of confidence in: (i) contaminant fate and transport modelling for releases to air and water which dictate exposure point concentrations for exposure assessment; (ii) substantive knowledge of ecological dietary/food chain relationships for exposure modelling; and (iii) conservatism of assumptions that err towards overestimating rather than underestimating exposure and risk (e.g., assumptions of statistical upper-bound exposure concentrations in water, assumption of no exposure reduction by way of receptor's ecological range for food extending beyond the HHERA LSA. Collectively, these practices provide moderate to high confidence that the risk estimates are not underestimated, and in the present case, an overall moderate level of confidence that the estimated health risk to terrestrial wildlife health as a result of the Project is low and not significant.

22.5.4.3.2 Aquatic Wildlife Health

The residual Project effects to aquatic wildlife health due to the Project activities during Operations, and by inference to other Project phases (Construction and Pre-Production, Reclamation and Closure, Post-Closure), are as follows:

- Duration: Long-term, the predicted Project-induced aquatic health risks are associated with the maximum operational performance year (i.e., maximum loadings release) and conservatively assumed to apply over the duration of the Operations phase until Reclamation and Closure. Water quality and associated risk may diminish after operational closure.

- Magnitude: Low, overall the proposed Project and associated activities are considered to present a low risk to aquatic health. Risk estimates in exceedance of target thresholds at Project assessment nodes were generally limited to the lower reaches of West Alexander Creek and immediately after the confluence with Alexander Creek for the aquatic community VC only. The limited geographic extent of the predicted risk estimates, the low to moderate potential magnitude of effect, and the conservative nature of the aquatic risk assessment (e.g., assumed maximum operations for loadings release, maximum 30-day rolling average for exposure concentrations) suggest that overall risks are low, despite predicted changes to surface water quality at Project assessment nodes.
- Geographic Extent: Local, the low estimated risk to aquatic health is limited to the watershed receiving treated water releases and is quickly further attenuated with transport and decay.
- Frequency: Continuous, the potential for low to negligible health risk to aquatic wildlife is most plausible during the operational lifetime of the mine during peak production emissions as represented by the Operations phase; similar but less exposure/risk scenarios are plausible during other phases of the Project.
- Reversibility: Reversible long-term, it is anticipated that low risk magnitude to aquatic wildlife health will diminish once the Project is closed and diminish further when reclaimed. In addition to mitigative reclamation processes, engineered solutions such as ongoing water treatment may further support the attainment of reversibility of low risk to aquatic health. Sediment quality and associated risk to benthic invertebrate may attenuate on a slower timescale in areas where sediments accumulate; in areas subject to scouring during freshet, the sediment may be episodically "refreshed".
- Context: Neutral, the sensitivity and resilience of aquatic wildlife health to the low magnitude of risk is considered neutral because the low exposures/risk are unlikely to adversely affect individuals or perturb local populations as a whole.

Determination of Significance

The residual effects of mine Operations activities (and by inference other less influential Project phases) to aquatic wildlife health are considered not significant. The risk estimates and their magnitude inherently consider operational activities, emissions, and other contaminant releases inherent to the predictive modelling of water quality and, for water birds secondarily for food via transport, fate and food chain modelling. The magnitude of health risk across all aquatic VCs considered herein was, in most cases, either negligible, low (and likely to be negligible due to conservatism of the assessment), or in isolated instances, moderate and geographically isolated to short reaches of immediate receiving waters at the mine footprint. Given the latter cases were conservatively estimated, attenuate quickly, and will be mitigated following mine closure (i.e., reversible), the Project-related risk to aquatic health is considered not significant. Consequently, the residual effects of the Project on aquatic wildlife health during all Project phases are considered not significant.

Likelihood and Confidence

Effects from Project activities that are determined to be not significant, as in the present case, do not warrant a characterization of likelihood.

Confidence respecting the conclusion of effect (aquatic wildlife health risk) being not significant considers the reliability of data and analytical methods used in the assessment of effects. The confidence level ascribed to aquatic wildlife health risk is moderate. The confidence level derives from consideration of confidence in: (i) contaminant fate and transport modelling for releases to air and water, which dictate exposure point concentration for exposure assessment; (ii) substantive knowledge of ecological dietary/food chain relationships for exposure modelling; and (iii) conservatism of assumptions that err towards overestimating rather than underestimating exposure and risk (e.g., assumptions of statistical upper-bound exposure concentrations in water, assumption of no exposure reduction by way of receptor's ecological range for food extending beyond the HHERA LSA. Collectively these practices provide a moderate to high confidence that the risk estimates are not underestimated, and in the present case, an overall moderate level of confidence that the estimated health risk to aquatic wildlife health as a result of the Project is low and not significant.

22.5.4.3.3 Human Health

The human health risks discussed in Section 22.5.4.2.3 were estimated in consideration of current use and rights-based Indigenous traditional use lifestyle scenarios. Indigenous communities represent the maximally exposed receptor, largely because of their increased presence on and use of traditional land, as well as increased consumption of country foods, as compared to non-Indigenous persons; as such, risk estimates calculated for Indigenous receptors are sufficiently conservative to infer maximal potential risk to non-Indigenous peoples also frequenting the HHERA LSA. Moreover, the rights-based use receptor lifestyle is inherently more engaged with land use and therefore offers the more conservative Indigenous risk scenario. This is corroborated by the fact that the maximum human health risk estimates computed and described in Section 22.5.4.3 all derive from the rights-based use receptor scenario (Note: all other human receptor risk values are presented in the HHERA technical support document; Appendix 22-A of the current chapter). The residual Project effects to human health due to the Project activities during Operations, and by inference to other Project phases (Construction and Pre-Production, Reclamation and Closure, Post-Closure), are as follows:

- Duration: Long-term, the predicted non-significant residual effects are only associated with conditions within the mine footprint or close to the haul road, which will be reclaimed.
- Magnitude: Low to negligible. The majority of identified contaminants of potential concern have been determined to pose a negligible, or low and likely negligible, risk to human health. For isolated locations, health risk was computed to be further elevated but these isolated scenarios derived from locations that would, in fact, not be realized (e.g., lifetime residence within the mine footprint or on/adjacent to the haul road).
- Geographic Extent: Local to discrete, potential residual low risks are restricted to the HHERA LSA; select elevated risk values are discrete and reflective of the mine footprint or haul road and are inferred to be non-detectable beyond the HHERA LSA.
- Frequency: Continuous, the potential for low to negligible risk to human health is most plausible during the operational lifetime of the mine as represented by the Operations phase; similar but less exposure/risk is plausible during other phases of the Project.
- Reversibility: Reversible long-term, it is anticipated that low risk magnitude to human health will be diminished (mitigated) and, in many cases, negated once the Project is reclaimed; this is especially true of risk estimates for critical receptor locations associated with the mine footprint and haul road.
- Context: High, the sensitivity and resilience of Indigenous and non-Indigenous people frequenting the Project area are able to understand the need to practice good food hygiene (e.g., wash food, not

collect food from haul road or mine footprint) and to respect institutional controls that would prohibit their presence on the mine footprint during the mine life (i.e., from construction to completion of reclamation). Therefore, human behaviour and practices in this context are expected to preclude exposure to the substances of interest at these locations until such time that reclamation restores physical habitat and acceptable exposure/risk.

Determination of Significance

The residual effects mine Operations activities (and by inference other less influential Project phases) to human health are considered not significant. The risk estimates and their magnitude inherently consider operational activities, emissions, and other contaminant releases intrinsic to the predictive modelling of water quality, air quality, and secondarily food via transport, fate and food chain modelling. The magnitude of health risk across all human receptors (Indigenous and non-Indigenous) is low to negligible, or in isolated instances, moderate to high, but not socially realistic or significant due to geographic locations of the exposure scenario within the mine footprint or adjacent to the mine haul road. Given that the latter cases will be mitigated and/or reclaimed following mine closure (i.e., reversible), the geographically isolated nature, and its temporal context (not permanent), the Project-related risk to human health is considered not significant. Consequently, the residual effects of the Project on human health during all Project phases are considered not significant.

Likelihood and Confidence

Effects from Project activities that are determined to be not significant, as in the present case, do not warrant a characterization of likelihood.

Confidence respecting the conclusion of effect (human health risk) being not significant considers the reliability of data and analytical methods used in the assessment of effects. The confidence level ascribed to human health risk is high. The confidence level derives from consideration of confidence in: (i) contaminant fate and transport modelling for releases to air and water which dictate exposure point concentration for exposure assessment; (ii) substantive Indigenous knowledge of traditional dietary/food chain relationships and exposure modelling for Indigenous people under current use and rights-based use scenarios; and (iii) conservatism of assumptions that err towards overestimating rather than underestimating exposure and risk (e.g., assumptions of statistical upper-bound exposure concentrations in water, assumption of lifetime exposure scenarios at each of the critical receptor locations). Collectively, these practices provide high confidence that the risk estimates are not underestimated, and in the present case, an overall high level of confidence that the estimated health risk to Indigenous and non-Indigenous people as a result of the Project is low and not significant.

22.5.4.4 Summary of Residual Effects Assessment

Residual effects and the selected mitigation measures, characterization criteria, likelihood, significance determination, and confidence are summarized in Table 22.5-9. As indicated, there are no significant residual effects to ecological or human health anticipated as a result of the Project.

Table 22.5-9: Summary of Residual Project Effects on Ecological and Human Health

Residual Effect	Project Phase(s)	Mitigation Measures	Summary of Residual Effects Characterization	Significance (Significant, Not Significant)	Confidence (High, Moderate, Low)
Changes to Terrestrial Wildlife Health due to Operations	Operations (plausible but likely low to negligible changes in other phases prior to reclamation)	Intrinsic to all mitigation contained in the Site Water Management Plan and Air Quality and Greenhouse Gas Management Plan.	Duration: Long-term Magnitude: Low Geographic Extent: Local Frequency: Continuous Reversibility: Reversible long-term Context: Neutral	Not Significant	Moderate
Changes to Aquatic Wildlife Health due to Operations	Operations (plausible but likely low to negligible changes in other phases prior to reclamation)	Intrinsic to all mitigation contained in Site Water Management Plan.	Duration: Long-term Magnitude: Low to moderate Geographic Extent: Local Frequency: Continuous Reversibility: Reversible Context: Neutral	Not Significant	Moderate
Changes to Human Health due to Operations	Operations (plausible but likely low to negligible changes in other phases prior to reclamation)	Intrinsic to all mitigation contained in the Site Water Management Plan and the Air Quality and Greenhouse Gas Management Plan.	Duration: Long-term Magnitude: Low Geographic Extent: Local Frequency: Continuous Reversibility: Reversible Context: High	Not Significant	High

22.6 Cumulative Effects Assessment

22.6.1 Overview of Residual Effects

Cumulative environmental effects are the result of Project residual environmental effects interacting with the effects of other past, present, and reasonably foreseeable future projects or activities to produce a combined/overlapping effect. The objective of the cumulative effects assessment is to consider overlapping effects for all residual adverse effects, not only those predicted to be significant (EAO, 2013). The assessment of cumulative effects on human and ecological health requires that:

- The Project results in a residual adverse environmental effect on the human and ecological health VC;

- A residual Project effect interacts cumulatively with effects from other projects or activities (i.e., an effect of the Project overlaps spatially and temporally with those of other projects or activities that have been or will be carried out);
- The other projects or activities have been or will be carried out and are not hypothetical; and
- The cumulative effect is likely to occur.

A cumulative effects assessment is required for the VC of ecological and human health risk, because there is a possibility that, despite mitigative measures inherent in the Project design and operation, potential for marginal Project residual effects (i.e., health risks) may remain. Therefore, it is of interest to understand the status of these marginal residual Project health risks when coupled with potentially overlapping additional environmental influences from other past, present, or reasonably foreseeable future projects or activities in the area.

22.6.2 Assessment Boundaries

The spatial, temporal, administrative, and technical boundaries for the cumulative effects assessment of human and ecological health are essentially the same as for Project Case as defined in Section 22.2.3, except for water quality associated with surface water assessment nodes. The Cumulative Case includes upstream mine discharge from Teck operations (Table 22.5-2); specifically, water quality nodes in Grave Creek (GC1, GC2, GC4), and Elk River downstream of confluence with Michel Creek (EV-ER1). Exposure scenarios developed from water quality reported for these specific nodes therefore reflect a cumulative effects assessment for risk estimates, denoted herein as the Cumulative Case.

Use of Temporal Cases

The temporal cases used in the assessment of cumulative effects on human and ecological health are described as follows:

1. Base Case – Describes the current status of the VC prior to the start of the Project, including all appropriate past and present projects and/or activities. The Base Case for human and ecological health is presented in the existing conditions section above (Section 22.4), with explicit reference to the fact that the Base Case generally reflects the contributions of past and present projects and/or activities;
2. Project Case – Describes the status of the VC with the Project in place, over and above the Base Case, as documented in the project effects assessment section above (Section 22.5); and
3. Cumulative Case – Describes the status of the VC as a result of the Project Case in combination with all reasonably foreseeable future projects and/or activities that could be carried out.

The comparison of the Project Case with the Cumulative Case allows the Project contribution to cumulative effects of all past, present, and reasonably foreseeable future projects and/or activities to be determined.

22.6.3 Identifying Past, Present, and Reasonably Foreseeable Projects and/or Activities

Descriptions of the past, present, and reasonably foreseeable future projects and/or activities for consideration in the cumulative effects assessment are provided in Chapter 5, Section 5.3.5.3.

Instances of Project interactive effects with other past, present or reasonably foreseeable future projects that may give rise to cumulative impacts to the receptor VCs of human and ecological health are those which release substances (either controlled or fugitive) to various environmental media (intermediate VCs) such as air, soil, water, sediment, groundwater, and food (biological tissues), and ultimately combine to influence the exposure scenarios of the human and ecological receptors. As per the methods identified in Chapter 5, previous chapters concerning intermediate VCs of this Application/EIS (specifically air quality, and surface water quality) have already established those other past, present, or reasonably foreseeable future projects or activities that identify plausible instances of cumulative interactions which: (I) offer no spatial or temporal overlap with other past, present, or reasonably foreseeable future projects or activities and therefore no cumulative effect (warranting no further consideration), (II) offer potential spatial or temporal overlap with other past, present, or reasonably foreseeable future projects or activities and therefore potential for adverse cumulative effects (warranting further consideration), or (III) offer confirmed spatial or temporal overlap with other past, present, or reasonably foreseeable future projects or activities and therefore potential for significant adverse cumulative effects (warranting further consideration) for assessment of cumulative effects.

Because the receptors VCs of human and ecological health are mediated through contact with intermediate VCs of environmental quality, the human and ecological risk assessment relies on the resultant assessment of other biophysical disciplines (e.g., surface water quality, air quality, soil quality, etc.) to first determine where the effects of the Project in combination with other past, present, or reasonably foreseeable future projects or activities overlap, and where warranted, the consequent media-specific quality. Thereafter, HHERA methods integrate this predicted information into health risk modelling procedures to determine the cumulative effects to receptor VCs of human and ecological health. Accordingly, the HHERA does not undertake here a separate process for identification of overlapping effects of the Project in combination with other past, present, or reasonably foreseeable future projects or activities. Rather, by using the predicted environmental data from the assessed intermediate VCs (specifically air quality and surface water quality), the HHERA aligns with and integrates those overlapping effects of the Project and other past, present, or reasonably foreseeable future projects or activities. The results of these separate cumulative effects assessments to ecological and human health VCs are discussed below.

22.6.4 Identification of Cumulative Effects

As previously described in Section 22.5.4.1, the HHERA incorporates predictive modelling conducted by other disciplines (i.e., air quality modelling and surface water quality modelling) and inherently considers any cumulative impacts to environmental quality incorporated into the predictive models developed by those disciplines. The Cumulative Case considers the potential effects associated with the proposed Project in addition to incremental changes associated with ongoing or reasonably foreseeable future projects or activities. The Cumulative Case is based on whatever reasonably foreseeable future projects included in the assessments conducted by the air and water quality disciplines, as predictions from these sources form the basis for the human health and ecological risk assessment.

In addition to the data inputs from other disciplines, the Cumulative Case considers predicted changes to soil and subsequent changes to vegetation and wildlife tissue associated with particulate deposition from other sources within the HHERA RSA. Cumulative incremental soil concentrations were estimated assuming baseline dustfall data represents predicted ongoing cumulative dustfall from sources aside from

the proposed Project. Cumulative particulate deposition was forecast for an additional 15 years to assess cumulative incremental changes to soil quality, and subsequent changes to vegetation and wildlife tissue.

22.6.4.1 Potential Cumulative Effects on Terrestrial Wildlife Health

The overall cumulative risk to terrestrial wildlife health is considered to be low. The Cumulative Case and application of additional dustfall and incremental changes to soil concentration results in marginal increase of predicted risk indices. Calculated hazard quotients for terrestrial mammalian and avian receptors assessed as part of the HHERA under the Cumulative Case are presented in Table 22.6-1. The majority of identified contaminants of potential concern have been determined to pose a low and likely negligible risk to terrestrial wildlife heath. Those with elevated risk are generally associated with receptor locations located within the Project footprint, as opposed to valued ecological habitat.

Table 22.6-1: Calculated HQs for Wildlife Receptors for the Cumulative Case

Receptor	Arsenic	Cadmium	Cobalt	Chromium	Selenium	Thallium
American Badger	0.014	0.17	0.32	0.011	0.32	0.029
American Marten	0.19	2**	2.6**	0.11	4.3*	0.3
Bighorn Sheep	0.015	0.023	0.0097	0.018	0.19	0.056
Canada Lynx	0.0000099	0.0083	0.025	0.000066	0.013	0.0000013
Deer Mouse	0.53	4.8**	0.28	0.13	12*	0.42
Elk	0.0027	0.0041	0.0018	0.0033	0.034	0.01
Grizzly Bear	0.00046	0.0031	0.0003	0.00027	0.074	0.0017
Least Chipmunk	0.21	1.3**	0.3	0.13	3.6*	0.39
Little Brown Myotis	0.21	2.1**	0.04	0.023	5*	0.084
Masked Shrew	8*	58**	7.7**	3.5*	140*	10*
Moose	0.0014	0.0018	0.0009	0.0017	0.12**	0.019
Northern River Otter	0.0011	0.05	0.006	0.001	7.4**	0.068
Snowshoe Hare	0.1	0.12	0.3	0.13	0.58	0.36
American Dipper	0.086	6.6**	4.6**	0.36	Aquatic	0.087
Canada Goose	0.047	0.042	1.3**	0.12	2.7**	0.041
Common Merganser	0.0077	0.037	0.027	0.0062	Aquatic	0.043
Common Raven	0.077	0.76	0.62	0.06	1.7*	0.0085
Mallard	0.033	0.39	0.93	0.092	Aquatic	0.047
Northern Goshawk	0.00023	0.22	1.2**	0.003	0.33	0.0000017

Receptor	Arsenic	Cadmium	Cobalt	Chromium	Selenium	Thallium
White-tailed Ptarmigan	0.064	0.48	0.18	0.072	1.2*	0.011

Notes:
Shaded cells indicate calculated hazard quotients greater than threshold of HQ=1.0.
* Calculated hazard quotient not appreciably different from Base Case conditions
** Calculated hazard quotient appreciably elevated relative to Base Case conditions. Result is suggestive of potential effect to VC.
Aquatic – Risks to aquatic waterbirds as a result of selenium exposure are considered in the aquatic wildlife health assessment. See Section 22.5.4.3.2.

22.6.4.2 Potential Cumulative Effects on Aquatic Wildlife Health

The cumulative assessment for potential effects to aquatic wildlife health is conducted somewhat differently than for terrestrial receptors (i.e., human and terrestrial wildlife health VCs). For cumulative assessment of aquatic wildlife health risks, a subset of modelled water quality prediction nodes is considered to be representative of the Cumulative Case, in that the predicted water quality is influenced primarily by surface water's source terms originating from other existing resource extraction projects.

Resource extraction activities have been ongoing in the Elk Valley since the early 1900s, and local watercourses with active pathways to current resource extraction projects show associated effects. There are three watercourses that will have potential cumulative effects from multiple mines in the Elk Valley:

- Harmer Creek (Harmer Creek flows into Lower Grave Creek and is impacted by Teck Coal's Elkview Operations);
- Michel Creek (Alexander Creek flows into Michel Creek, is also impacted by Teck Coal's Coal Mountain Operations); and
- Elk River (Elk River receives runoff from all five current and past producing Teck Coal Operations, and several proposed coal projects).

The predictive water quality model incorporates geochemical source terms for all flows in all watersheds within the Aquatic LSA. Water quality model reporting nodes located along the watercourses indicated above (i.e., ER_1 GC_1, GC_2, and GC_4) are inherently an assessment of cumulative effects.

Calculated incremental change in risk estimates, particularly for selenium, at cumulative assessment nodes in Harmer Creek (GC_4) and Lower Grave Creek (GC_1 and GC_2) are the function of an artefact in the water quality model. The geochemical source terms for flow from Harmer Creek used in the water quality model for selenium was 50 micrograms per litre (µg/L). Baseline assessment was carried out using the 95th percentile of the available empirical baseline surface water quality data from Grave Creek after the confluence with Harmer Creek ([Se]=28.1 µg/L).

According to the water quality modelling report, Project infrastructure is planned in the Grave Creek drainage on the north end of the site but is not anticipated to be impacted by mining activities other than withdrawals for mine water supply. Baseline level water quality is expected to be discharged in Upper Grave Creek, which joins with Harmer Creek, which receives discharges from the Teck Coal's Elkview Operations. Lower Grave Creek discharges to the Elk River upstream of the confluence with Michel Creek.

The Crown Mountain Water and Load Balance predicts essentially no water quality impacts to the Grave Creek Watershed. Changes to surface water quality in the Elk River and Lake Koocanusa due to the Project are predicted to be negligible as compared with background conditions (Chapter 11, Section 11.5.4.2). As discussed in Section 22.4.2.2.2, it is reasonable to assume that sediment quality in these areas will have been affected by effluent discharge from other coal extraction projects in the area and that calculated hazard quotients may exceed a value of HQ=1.0. Given that changes to water quality in the Elk River due to the Project are predicted to be negligible, no changes to sediment quality in the Elk River are anticipated.

Overall, the Cumulative Case suggests a moderate risk to aquatic wildlife health at cumulative assessment nodes impacted by drainage from Teck Coal's Elkview Operations. Calculated hazard quotients for aquatic receptors assessed are presented in Table 22.6-2 and Table 22.6-3 for surface water and sediment exposures, respectively. Risk estimates in exceedance of target thresholds at cumulative assessment nodes predict moderate potential residual effects to the aquatic community, amphibians, and sensitive fish species at these locations.

The calculated HQs for selenium are suggestive of a high potential magnitude of effect associated with historic and ongoing mining activities in the Harmer Creek watershed (i.e., Teck Coal's Elkview Operations). Risk estimates in exceedance of target threshold are calculated for benthic invertebrates associated with direct sediment contact as well as aquatic invertebrates associated with direct contact with surface water at all cumulative assessment nodes. Maximum calculated HQs are 9.5 and 15.5 for surface water and sediment exposure, respectively. Maximum HQs are calculated at assessment node GC-4, located in Harmer Creek upstream of the confluence with Grave Creek.

Table 22.6-2: Calculated Hazard Quotients for Aquatic Receptor VCs Associated with Surface Water for Cumulative Case

		Aquatic Community			Amphibians			Sensitive Fish Species			Waterbird
		Cd	Co	Se	Cd	Co	Se	Cd	Co	Se	Se
Assessment Node	AC_1	0.08	0.8	0.44	0.04	0.01	0.17	0.05	0.01	0.12	0.01
	AC_2	0.09	0.92	0.46	0.05	0.01	0.18	0.06	0.01	0.12	0.01
	AC_3	0.15	1.7**	0.6	0.08	0.02	0.23	0.1	0.01	0.16	0.01
	AC_4	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	AC_5	0.73	9.4**	1.93**	0.4	0.11	0.74	0.48	0.06	0.51	0.05
	AC_6	0.73	9.4**	1.91**	0.4	0.11	0.74	0.48	0.06	0.5	0.05
	ER1 [C]	0.01	0.06	1.76*	<0.01	<0.01	0.68	0.01	<0.01	0.46	0.04
	GC_1 [C]	0.03	0.03	4.82*	0.02	<0.01	1.85*	0.02	<0.01	1.27*	0.12
	GC_2 [C]	0.04	0.03	6*	0.02	<0.01	2.31*	0.02	<0.01	1.58*	0.15
	GC_3	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	GC_4 [C]	0.04	0.05	9.5[u]	0.02	<0.01	3.65[u]	0.03	<0.01	2.5[u]	0.23
	GC_5	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	GC_6	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	GC_7	0.02	0.01	0.31	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01
	GC_8	0.02	0.01	0.3	0.01	<0.01	0.12	0.01	<0.01	0.08	0.01

Notes for Table 22.6-2:
C = Locations inherently considered as cumulative assessment nodes as predicted water quality is influenced primarily by surface water source terms originating from other existing resource extraction projects.
Shaded cells indicate calculated hazard quotients greater than threshold of HQ=1.0.
* Calculated hazard quotient not appreciably different from Base Case conditions
** Calculated hazard quotient appreciably elevated relative to Base Case conditions. Result is suggestive of potential effect to VC.
u - Apparent difference between the baseline and cumulative assessment is owing to an artefact of the water quality model source terms and is not reflective of a predicted change in surface water quality.

Table 22.6-3: Calculated Hazard Quotients for Benthic Community VCs Associated with Sediment for Cumulative Case

Assessment Node	Aquatic Community (Benthic Invertebrates)		
	Cd	Co	Se
AC_1	0.3	0.1	0.7
AC_2	0.3	0.1	0.8
AC_3	0.5	0.1	1.0
AC_4	0.1	<0.1	0.5
AC_5	2.7**	0.8	3.2**
AC_6	2.7**	0.8	3.1**
ER1 [C]	<0.1	<0.1	2.9**
GC_1 [C]	0.1	<0.1	7.9**
GC_2 [C]	0.1	<0.1	9.8**
GC_3	0.1	<0.1	0.5
GC_4 [C]	0.2	<0.1	15.5**
GC_5	0.1	<0.1	0.5
GC_6	0.1	<0.1	0.5
GC_7	0.1	<0.1	0.5
GC_8	0.1	<0.1	0.5

Notes:
C = Locations inherently considered as cumulative assessment nodes as predicted water quality is influenced primarily by surface water source terms originating from other existing resource extraction projects.
Shaded cells indicate calculated hazard quotients greater than threshold of HQ=1.0.
* Calculated hazard quotient not appreciably different from Base Case conditions
** Calculated hazard quotient appreciably elevated relative to Base Case conditions. Result is suggestive of potential effect to VC.

22.6.4.3 Potential Cumulative Effects on Human Health

The overall cumulative effects related to human health risk is considered to be low. Calculated hazard quotients and incremental lifetime cancer risks for human receptors are presented in Table 22.6-4 and Table 22.6-5, respectively. Application of additional dustfall and subsequent changes to soil, vegetation, and tissue results in a negligible change in predicted risk estimates compared to the Baseline and Project Cases. Maximum incremental increase in HQ between the Project and cumulative assessments is 0.005. Maximum incremental increase in ILCR between the Project and cumulative assessment is 1.7E-6.

Additional details on the interpretation of risk estimates for individual COPCs is presented in Section 22.4.2.2 and Appendix 22-A.

Table 22.6-4: Calculated HQs for Human Receptors at Critical Receptors Locations under the Cumulative Case

Receptor Location	Arsenic	Cadmium	Cobalt	Chromium	Nickel	Selenium
CRID#1	0.0017	0.703	1.25	1.69	0.656	0.00772
CRID#2	0.0025	1.02*	1.27*	1.73*	0.702	0.0399
CRID#3	0.0024	0.932	1.24*	1.74*	0.68	0.0253
CRID#4	0.0023	1.08*	3**	1.77*	0.674	0.0205
CRID#5	0.0025	1.03*	1.29*	1.73*	0.669	0.00593
CRID#6	0.0022	0.81	1.16*	1.75*	0.65	0.00192
CRID#7	0.0022	0.808	1.18*	1.75*	0.651	0.00189
CRID#8	0.0022	0.806	1.18*	1.75*	0.651	0.00189
CRID#9	0.0022	0.816	1.32*	1.75*	0.651	0.00189
CRID#10	0.0027**	1.85**	5.71**	1.76*	1.38**	0.00307
CRID#11	0.0024	1.25**	2.99**	1.75*	0.992	0.00244
CRID#12	0.0022	1.88**	21.3**	1.8*	0.65	0.00189
CRID#13	0.0017	0.703	1.25*	1.69*	0.656	0.00772
CRID#14	0.0024	1.33**	3.34**	1.75*	1.04**	0.00253
CRID#15	0.0051**	8.15**	33.3**	1.9*	5.26**	0.00838

Notes:
Hazard quotients presented represent maximum calculated hazard quotient of the various human receptors assessed for each critical receptor location.
Shaded values indicated HQs in exceedance of HQ=1.0

* Calculated hazard quotient not appreciably different from Base Case conditions

** Calculated hazard quotient appreciably elevated relative to Base Case conditions. Result is suggestive of potential effect to VC.

Table 22.6-5: Calculated ILCRs for Human Receptors at Critical Receptors Locations under the Cumulative Case

Critical Receptor Location	Arsenic	Cadmium	Chromium	Nickel	Benzo[a]pyrene
CRID #1	4.8E-4*	2.6E-6	7.1E-6	1.1E-6	6.3E-8
CRID #2	8.9E-4*	1.8E-4**	1.2E-4**	5.7E-6	6.3E-8
CRID #3	8.3E-4*	7.6E-5**	5.7E-5**	3.0E-6	6.3E-8
CRID #4	8.1E-4*	3.9E-4**	2.7E-4**	1.1E-5**	6.4E-8
CRID #5	8.6E-4*	4.0E-5**	3.2E-5*	2.1E-6	7.5E-9
CRID #6	7.3E-4*	6.0E-6	9.3E-6	1.2E-6	6.3E-8
CRID #7	7.3E-4*	6.3E-6	9.1E-6	1.1E-6	6.3E-8
CRID #8	7.3E-4*	3.6E-6	7.1E-6	1.1E-6	6.3E-8
CRID #9	7.3E-4*	1.1E-5**	9.2E-6	1.1E-6	6.3E-8
CRID #10	9.7E-4**	1.2E-5**	9.6E-6	1.2E-6	6.3E-8
CRID #11	8.4E-4*	1.7E-6	6.5E-6	1.1E-6	6.3E-8
CRID #12	7.3E-4*	1.2E-4**	5.1E-5**	1.9E-6	6.3E-8
CRID #13	4.8E-4*	2.5E-6	7.1E-6	1.1E-6	6.3E-8
CRID #14	8.6E-4*	2.6E-6	6.8E-6	1.1E-6	6.3E-8
CRID #15	2.1E-3**	4.0E-3**	1.0E-3**	4.5E-5**	7.8E-8

Notes:
ILCRs presented are maximum composite ILCRs of the various human receptors assessed for each critical receptor location.
Shaded values indicated ILCRs in exceedance of 1:100,000

* Calculated hazard quotient not appreciably different from Base Case conditions

** Calculated hazard quotient appreciably elevated relative to Base Case conditions. Result is suggestive of potential effect to VC.

22.6.5 Mitigation for Cumulative Effects

The assessment of cumulative health risk to ecological receptors and people associated with local land use inherently considers the Project mitigation measures that are engineered and operationally planned within the Project and are reflected in the fate and transport modelling of the air quality modelling (Chapter 6) and the surface water quality modelling (Chapter 11). A wide array of design mitigation measures are therefore directly reflected in the predicted environmental quality for surface water and air under the Cumulative Case, and then secondarily integrated when predicting how these media affect soil, plant/animal tissue (i.e., food), and sediment quality. Therefore, to a large extent, various aspects of the potential linkages between Project activity and health risk to valued components have been mitigated before the health risks are quantified.

Consideration of mitigation associated with the confluence of waterborne contaminants in different reaches of the watershed has not been considered and is likely impractical. However, in light of results presented above for the Cumulative Case, further mitigation may be considered at the mixing zone where Project treated water is discharged.

Further opportunity to mitigate health risk to individual receptors may be possible through mitigation of exposure, which is an essential component of any toxicological health risk; this would fundamentally mean mitigative measures that either further reduce the exposure point concentration of substances to ecological receptors and people (e.g., use of dust suppression along haul roads to decrease fugitive airborne particulate concentrations and dispersion), or through reduction of the frequency/duration by which ecological receptors and people may come into contact with the substances through contact with certain media, such as water, air, and food. This is particularly relevant for critical locations near the haul road and on the mine footprint where human receptors should be limited to workers, and not in a domestic/residential capacity.

The risk assessment scenarios described herein have used conservative exposure assumptions which intentionally err in overestimating, rather than underestimating, health risk. This is the case for both ecological and human health risk, where the receptors (i.e., a wildlife species or local people on the land) are assumed to receive all their exposure at locations on or near the Project continuously throughout their life. It is likely that such scenarios are unlikely and that a degree of “avoidance” (either intentional or unintentional) may mitigate exposure and risk through a reduction of exposure “frequency”. In some instances where the mine footprint and major works preclude land use or a receptor’s presence during the mine’s operational life, institutional mitigative measures such as fencing or operational policies may be invoked until the mine is closed and fully reclaimed in order to mitigate potential exposures and health risk.

22.6.6 Characterization of Residual Cumulative Effects

22.6.6.1 Terrestrial Wildlife Health

As noted in the discussion in Section 22.5.4.3.1, the residual cumulative effects (health risk) to terrestrial wildlife under the cumulative exposure scenario is largely reflective of that documented for the Project scenario, despite the inherent inclusion of ancillary emissions and releases to predictive air and water quality and receptor exposure assessment. In isolated cases of elevated risk (e.g., masked shrew,

$HQ_{cadmium}$ = 58), the risk level is the same as that derived for the Project (i.e., an increment above Baseline, but virtually the same as the Project case) but is limited in geographic location (e.g., for the masked shrew the hypothetical exposure occurs within the mine footprint). The residual cumulative effects to terrestrial wildlife health due to cumulative activities during Operations, and by inference to other Project phases (Construction and Pre-Production, Reclamation and Closure, Post-Closure) within the Cumulative Case, are as follows:

- Duration: Long-term, the predicted non-significant residual cumulative effects that are more notable to specific species with small ranges (e.g., masked shrew) are only associated with conditions within the mine footprint or close to the haul road, which will be reclaimed.
- Magnitude: Low to negligible, for most substances of interest and locations of interest, there is no discernible change from baseline in health risk to populations of terrestrial wildlife. For isolated locations, VC individuals and substances, health risk is considered low to moderate in the mine footprint or haul road, but low in the context of the VC population.
- Geographic Extent: Local to discrete, potential effects to are restricted to the HHERA LSA and largely to the mine footprint or haul road and are inferred to be non-detectable outside of the HHERA LSA.
- Frequency: Continuous, the potential for low to negligible health risk to terrestrial wildlife is most plausible during the operational lifetime of the mine during Operations; similar but with less exposure/risk are plausible during other phases of the Project.
- Reversibility: Reversible long-term, it is anticipated that low risk magnitude to terrestrial wildlife health will be diminished (mitigated), and in many cases negated, once the Project is reclaimed.
- Context: Neutral, the sensitivity and resilience of the terrestrial wildlife health to the low magnitude of risk is considered neutral because the low exposures/risk are unlikely to adversely perturb local populations. An exception to this may be for non-ranging species (e.g., masked shrew) in key locations such as the mine footprint or haul road; however, the physical disruption to these areas is likely to preclude their presence and therefore preclude exposure to the substances of interest at these locations until such time that reclamation restores physical habitat and acceptable exposure/risk.

Determination of Significance

The residual cumulative effects of the Project in combination with other past, present, and reasonably foreseeable future projects or activities during Operations (and by inference, cumulative effects from other less influential Project phases) to terrestrial wildlife health are considered not significant. The risk estimates and their magnitude inherently consider both Project and emissions, and other contaminant releases intrinsic to the predictive modelling of water quality, air quality and secondarily food via transport, fate and food chain modelling. The magnitude of health risk across all terrestrial VCs considered herein was either negligible, low (and likely to be negligible due to conservatism of the assessment), or in isolated instances (e.g., masked shrew), moderate to high but not ecologically significant due to geographic locations of the exposure scenario within the mine footprint or adjacent to the mine haul road. Given the latter cases will be mitigated and/or reclaimed following mine closure (i.e., reversible), the geographically isolated nature, lack of population significance, and its temporal (not permanent), and the generally low risks to terrestrial wildlife health from the Cumulative Case. The residual cumulative effects of the Project in combination with other past, present, and reasonably foreseeable future projects or activities on terrestrial wildlife health during all Project phases are considered not significant.

Likelihood and Confidence

Cumulative effects that are determined to be not significant, as in the present case, do not warrant a characterization of likelihood.

Confidence respecting the conclusion of effect (terrestrial wildlife health risk) being not significant considers the reliability of data and analytical methods used in the assessment of effects. The confidence level ascribed to cumulative terrestrial wildlife health risk is moderate. The confidence level derives from consideration of confidence in: (i) contaminant fate and transport modelling for releases to air and water which dictate exposure point concentration for exposure assessment; (ii) substantive knowledge of ecological dietary/food chain relationships for exposure modelling; and (iii) conservatism of assumptions that err towards overestimating rather than underestimating exposure and risk (e.g., assumptions of statistical upper-bound exposure concentrations in water, assumption of no exposure reduction by way of receptor's ecological range for food extending beyond the Terrestrial LSA). Collectively, these practices provide a moderate to high confidence that the risk estimates are not underestimated, and in the present case, an overall moderate level of confidence that the estimated health risk to terrestrial wildlife health as a result of the cumulative activities of the Project in combination with other past, present, and reasonably foreseeable future projects or activities is low and not significant.

22.6.6.2 Aquatic Wildlife Health

The residual cumulative effects (health risk) to aquatic wildlife under the cumulative exposure scenario is largely reflective of that documented for the Project scenario (Section 22.5.4.2.2), despite the inherent inclusion of ancillary emissions and releases to predict water quality and receptor exposure assessment. The residual cumulative effects to aquatic wildlife health due to cumulative activities during Operations, and by inference to other Project phases (Construction and Pre-Production, Reclamation and Closure, Post-Closure) within the Cumulative Case, are as follows:

- Duration: Long-term, the predicted Project-induced aquatic health risks are associated with the maximum operational performance year (i.e., maximum loadings release) and conservatively assumed to apply over the duration of the Operations phase until reclamation. Water quality and associated risk may diminish after operational closure.
- Magnitude: Low to moderate, overall the proposed Project and associated activities are considered to present a low risk to aquatic health, with isolated instances of moderate risk (HQ = 9.4 for cobalt) to the aquatic invertebrate pelagic community only, following discharge of treated water. This quickly attenuates after assessment nodes AC5 and AC6 (i.e., lower reaches of West Alexander Creek and immediately after the confluence with Alexander Creek). As noted the prediction of an elevated hazard quotient for selenium (HQ = 9.5) at Grave Creek (water quality node GC4) under the cumulative scenario is an artefact of water quality modelling not replicating baseline empirical data. Importantly, this location receives no input from the Project, but does receive input from Teck Coal's operations. Neither the baseline cobalt HQ = 5.6 (moderate risk) or the modelled cumulative risk are associated with the Project. The limited geographic extent of the predicted risk estimates, the low to moderate potential magnitude of effect, and the conservative nature of the aquatic risk assessment (e.g., assumed maximum operations for loadings release, maximum 30-day rolling average for exposure concentrations) suggest that overall risks are low despite predicted changes to surface water quality at Project assessment nodes.
- Geographic Extent: Local, the low estimated risk to aquatic health is limited to the watershed receiving treated water releases and is quickly further attenuated with downstream transport and dilution forces from additional surface water flows. .

- Frequency: Continuous, the potential for low to negligible health risk to aquatic wildlife is most plausible during the operational lifetime during peak production emissions in the Operations phase; similar but less exposure/risk scenarios are plausible during other phases of the Project.
- Reversibility: Reversible long-term, it is anticipated that low risk magnitude to aquatic wildlife health will diminish once the Project is closed and diminish further when reclaimed. In addition to mitigative reclamation processes, engineered solutions such as ongoing water treatment may further support the attainment of reversibility of low risk to aquatic health. Sediment quality and associated risk to benthic invertebrates may attenuate on a slower timescale in areas where sediments accumulate; in areas subject to scouring during freshet, the sediment may be episodically "refreshed".
- Context: Neutral, the sensitivity and resilience of aquatic wildlife health to the low to moderate magnitude of risk is considered neutral because the low to moderate exposures/risk, the conservative nature of their derivation, and geographical limitations infer the risk is unlikely to adversely affect individuals or perturb local populations as a whole.

Determination of Significance

The residual cumulative effects of the Project in combination with other past, present, and reasonably foreseeable future projects or activities during Operations (and by inference other less influential Project phases) to aquatic wildlife health are considered not significant. The cumulative effect (risk estimates) and their magnitude inherently consider water releases from the Project and other local operational activities inherent to the predictive of water quality model and, for water birds predicted food quality via transport, fate and food chain modelling. The magnitude of health risk across all aquatic VCs considered herein was in most cases either negligible, low (and likely to be negligible due to conservatism of the assessment), or in isolated instances, moderate and geographically isolated to short reaches of immediate receiving waters at the mine footprint. Given the latter cases were conservatively estimated, attenuate quickly, and will be mitigated following mine closure (i.e., reversible), the residual cumulative effects of the Project in combination with other past, present, or reasonably foreseeable future projects or activities on aquatic wildlife health during all Project phases are considered not significant.

Likelihood and Confidence

Cumulative effects that are determined to be not significant, as in the present case, do not warrant a characterization of likelihood.

Confidence respecting the conclusion of effect (aquatic wildlife health risk) being not significant considers the reliability of data and analytical methods used in the assessment of effects. The confidence level ascribed to cumulative aquatic wildlife health risk is moderate. The confidence level derives from consideration of confidence in: (i) contaminant fate and transport modelling for releases to air and water which dictate exposure point concentration for exposure assessment; (ii) substantive knowledge of ecological dietary/food chain relationships for exposure modelling; and (iii) conservatism of assumptions that err towards overestimating rather than underestimating exposure and risk (e.g., assumptions of statistical upper-bound exposure concentrations in water, assumption of no exposure reduction by way of receptor's ecological range for food extending beyond the Aquatic LSA). The conservative nature of the water quality model is further illustrated by the unintended but transparent prediction of aqueous selenium at node GC4 that exceeds the baseline empirical data (see discussion of Magnitude, above). Collectively, these practices provide a moderate to high confidence that the risk estimates are not

underestimated, and in the present case, an overall moderate level of confidence that the estimated health risk to aquatic wildlife as a result of the cumulative activities of the Project and other past, present, and reasonably foreseeable future projects or activities is low and not significant.

22.6.6.3 Human Health

Similar to the Project case, the cumulative effects to human health (i.e., risks) discussed in Section 22.5.4.3.3 were conducted in consideration of current use and rights-based Indigenous traditional use lifestyle scenarios and are sufficiently conservative to infer maximal potential risk to non-Indigenous peoples also frequenting the HHERA RSA. Characterization and the way the risk estimates were generated is exactly the same in both cases, with the exception of use of predicted exposure point concentrations that account for industrial activities/releases in addition to those of the Project. To this end, the overall cumulative effects related to human health risk is considered to be low. Maximum incremental increase in HQ between the Project Case and Cumulative Case assessments is 0.005 and negligible. Maximum incremental increase in ILCR between the Project Case and Cumulative Case assessment is 1.7E-6, and also negligible.

Accordingly, the residual cumulative effects to human health due to cumulative activities during Operations, and by inference to other Project phases (Construction and Pre-Production, Reclamation and Closure, Post-Closure) within the Cumulative Case, are as follows:

- Duration: Long-term, the predicted non-significant residual cumulative effects are only associated with conditions within the mine footprint or close to the haul road, which will be reclaimed.
- Magnitude: Low to negligible. The majority of identified contaminants of potential concern have been determined to pose a negligible or low and likely negligible risk to human health. For isolated locations, health risk was computed to be further elevated but these isolated scenarios derived from locations that would, in fact, not be realized (e.g., lifetime residence within the mine footprint or on/adjacent to the haul road).
- Geographic Extent: Local to discrete, potential residual low risks are restricted to the HHERA LSA; select elevated risk values are discrete and reflective of the mine footprint or haul road and are inferred to be non-detectable beyond the HHERA LSA.
- Frequency: Continuous, the potential for low to negligible risk to human health is most plausible during the operational lifetime of the mine during the Operations phase; similar but less exposure/risk is plausible during other phases of the Project.
- Reversibility: Reversible long-term, it is anticipated that low risk magnitude to human health will be diminished (mitigated) and in many cases negated once the Project is reclaimed; this is especially true of risk estimates for critical receptor locations associated with the mine footprint and haul road.
- Context: High, the sensitivity and resilience of Indigenous and non-Indigenous people frequenting the Project area are able to understand the need to practice good food hygiene (e.g., wash food, not collect food from haul road or mine footprint) and to respect institutional controls that would prohibit their presence on the mine footprint during the mine life (i.e., from construction to completion of reclamation). Therefore, human behaviour and practices in this context are expected to preclude exposure to the substances of interest at these locations until such time that reclamation restores physical habitat and acceptable exposure/risk.

Determination of Significance

The residual cumulative effects of the Project in combination with other past, present, and reasonably foreseeable future projects or activities during Operations (and by inference other less influential Project phases) to human health are considered not significant. The risk estimates and their magnitude inherently consider operational activities, emissions, and other contaminant releases intrinsic to the predictive modelling of water quality, air quality and secondarily food via transport, fate and food chain modelling. The magnitude of health risk across all human receptors (Indigenous and non-Indigenous) is low to negligible, or in isolated instances, moderate to high but not socially realistic or significant due to geographic locations of the exposure scenario within the mine footprint or adjacent to the mine haul road. Given the latter cases will be mitigated and/or reclaimed following mine closure (i.e., reversible), the geographically isolated nature, and its temporal context (not permanent), the residual cumulative effects of the Project in combination with other past, present, and reasonably foreseeable future projects or activities on human health during all Project phases is considered not significant.

Likelihood and Confidence

Cumulative effects that are determined to be not significant, as in the present case, do not warrant a characterization of likelihood.

Confidence respecting the conclusion of effect (human health risk) being not significant considers the reliability of data and analytical methods used in the assessment of effects. The confidence level ascribed to human health risk is high. The confidence level derives from consideration of confidence in: (i) contaminant fate and transport modelling for releases to air and water which dictate exposure point concentration for exposure assessment: (ii) substantive Indigenous knowledge of traditional dietary/food chain relationships and exposure modelling for Indigenous people under current use and rights-based use scenarios; and (iii) conservatism of assumptions that err towards overestimating rather than underestimating exposure and risk (e.g., assumptions of statistical upper-bound exposure concentrations in water, assumption of lifetime exposure scenarios at each of the critical receptor locations). Collectively these practices provide a high confidence that the risk estimates are not underestimated, and in the present case, an overall high level of confidence that the estimated health risk to Indigenous and non-Indigenous people as a result of the cumulative activities of the Project in combination with other past, present, or reasonably foreseeable future projects or activities is low and not significant.

22.6.7 Summary of Cumulative Effects Assessment

Residual cumulative effects and the selected mitigation measures, characterization criteria, likelihood, significance determination, and confidence are summarized in Table 22.6-6. As indicated, there are no significant residual cumulative effects to ecological or human health anticipated as a result of the Project in combination with other past, present, and reasonably foreseeable future projects or activities.

Table 22.6-6: Summary of Residual Cumulative Effects on Ecological and Human Health

Residual Effect	Project Phase(s)	Mitigation Measures	Summary of Residual Cumulative Effects Characterization	Significance (Significant, Not Significant)	Confidence (High, Moderate, Low)
Changes to Terrestrial Wildlife Health due to Operations	Operations (plausible but likely low to negligible changes in other phases prior to reclamation)	Intrinsic to: • Site Water Management Plan • Air Quality and Greenhouse Gas Management Plan	Duration: Long-term Magnitude: Low Geographic Extent: Local Frequency: Continuous Reversibility: Reversible long-term Context: Neutral	Not Significant	Moderate
Changes to Aquatic Wildlife Health due to Operations	Operations (plausible but likely low to negligible changes in other phases prior to reclamation)	Intrinsic to: • Site Water Management Plan	Duration: Long-term Magnitude: Low to moderate Geographic Extent: Local Frequency: Continuous Reversibility: Reversible Context: Neutral	Not Significant	Moderate
Changes to Human Health due to Operations	Operations (plausible but likely low to negligible changes in other phases prior to reclamation)	Intrinsic to: • Site Water Management Plan • Air Quality and Greenhouse Gas Management Plan	Duration: Long-term Magnitude: Low Geographic Extent: Local Frequency: Continuous Reversibility: Reversible Context: High	Not Significant	High

22.7 Follow-up Strategy

No specific follow-up activities are required with respect to the human and ecological health assessment. Planned follow-up monitoring requirements associated with potential changes to the biophysical environment, as described in other chapters of the Application/EIS, can be considered as suitable inputs to revisit the predictions of the HHERA and its associated models. Biophysical monitoring of surface water, sediment, air quality, and possibly plant/animal tissue can be used as inputs to the multimedia food web and exposure model to validate the outputs of the HHERA (i.e., risk estimates) and identify whether additional risk management actions are necessary. A summary of follow-up programs that will be used to verify the predictions of the HHERA and to monitor the effectiveness of the associated mitigation measures is provided in Table 22.7-1.

Table 22.7-1: Summary of Follow-up Programs Relevant to the HHERA

Discipline	Description of Follow-up Program	Location in Application/EIS
Atmospheric Environment	To assess changes in ambient air quality over the course of the Project, site-specific monitoring will be implemented as part of an Air Quality Monitoring Program (AQMP). The AQMP is expected to evaluate changes in ambient air quality to confirm that regulatory compliance measures are met, and to allow for the development of adaptive management strategies through continued improvement of mitigation measures.	• Chapter 6, Section 6.7.1 • Chapter 33, Section 33.4.1.1.1
Soil Quality	Soil will be monitored for soil quality, throughout the life of the Project. Throughout each Project phase, monitoring results will be compared to baseline data to assess the effectiveness of mitigation measures to support the evaluation and improvement of soil practices, and inform the development of adaptive management measures, should they be required.	• Chapter 8, Section 8.7 • Chapter 33, Section 33.4.1.9
Groundwater Quality	A groundwater monitoring program will be conducted throughout Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure. Groundwater monitoring data will enable verification of the accuracy of the predicted Project effects at each potentially affected catchment. Comparison to the existing model and periodic model updates (if necessary) will be conducted to improve the level of confidence in the predicted Project effects.	• Chapter 9, Section 9.7 • Chapter 33, Section 33.4.1.8
Surface Water Quality	A comprehensive surface water quality monitoring program will be developed and implemented to facilitate an ongoing examination of surface water quality within the receiving watercourses downstream of the Project footprint, in addition to reference sites upstream of the Project. The results of the monitoring program will be used to evaluate the effectiveness of the proposed mitigation measures and determine whether additional mitigation measures or adaptive management strategies are needed.	• Chapter 11, Section 11.7 • Chapter 33, Section 33.4.1.
Aquatic Health	The follow-up strategy for aquatic health will involve the development of a comprehensive Aquatic Effects Monitoring Program (AEMP),	• Chapter 12, Section 12.7 • Chapter 33, Section 33.4.1.5.7

Discipline	Description of Follow-up Program	Location in Application/EIS
	which will include surface water quality, sediment, benthic invertebrate, and fish tissue monitoring (in fish bearing watercourses). The aim of the AEMP is to assess if mitigations are effective and will provide an adaptive management framework to support early detection of effects, and adequate response procedures for protecting fish and fish habitat	

22.8 Summary and Conclusions

The Crown Mountain Coking Coal Project (the Project) will involve changes in land use, and potential changes in water quality, air quality, soil quality and sediment quality, and certain food quality which, through various pathways, may influence the valued components of human health or ecological health. As result of this potential, a human health and ecological risk assessment was conducted to quantitatively assess the collective effects (health risks) of potential changes in quality to the above-noted media, using various exposure models and foodchain models. Quantitative expressions of health risk in the form of HQs and ILCRs were derived based on accepted practices and guidance from Health Canada, Environment and Climate Change Canada, and CCME.

The thresholds for determining the significance of human and ecological risk estimates were established with consideration for federal/provincial policy, conservatism of the risk assessment process and uncertainties inherent in the process. This approach was applied for the effects assessment of the Base Case, Project Case, and Cumulative Case. Descriptors for the numerical expressions of risk are as follows in Table 22.8-1 and Table 22.8-2:

Table 22.8-1: Categories of Magnitude of Effect in Terrestrial and Aquatic Wildlife Health Risk Assessment

Risk Estimate	Negligible	Low	Moderate	High
Hazard Quotient	No change, below applicable guidelines, or HQ≤1.0	1.0 < HQ ≤ 5	5 < HQ ≤ 10	HQ > 10

Table 22.8-2: Categories of Magnitude of Effect for Human Health Risk

Risk Estimate	Negligible	Low	Moderate	High
Hazard Quotient (Non-carcinogens)	No change, below applicable guidelines, or HQ<1.0	1.0 < HQ ≤ 5	5 < HQ ≤ 10	HQ > 10
ILCR (Carcinogens)	No change, below applicable guidelines, or ILCR < $1E^{-5}$	$1E^{-5}$ < ILCR ≤ $5E^{-5}$	$5E^{-5}$ < ILCR ≤ $1E^{-4}$	ILCR > $1E^{-4}$

Based on consideration of the health risk magnitude, inherent conservatism of the risk assessment (i.e., cautionary approach to overestimate rather than underestimate risk), and uncertainties, the residual Project effects, significance of determination, and confidence levels are summarized as follows:

- Terrestrial Wildlife Health – No significant residual effect associated with the Project with a moderate level of confidence;
- Aquatic Wildlife Health - No significant residual effect associated with the Project with a moderate level of confidence; and
- Human Health - No significant residual effect associated with the Project with a high level of confidence.

Based on the results of the assessment of the Operations phase of the Project, the residual effects on human and ecological health related to activities to be conducted during Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure are considered not significant, with a moderate to high level of confidence.

A cumulative effects assessment was also conducted using the same methods as described for the Project Case to understand the status of residual Project health risks when coupled with potentially overlapping additional environmental influences from other past, present, or reasonably foreseeable future projects or activities in the area.

Residual cumulative effects significance of determination, and confidence are summarized as follows:

- The residual cumulative effects of the Project in combination with those of other past, present, and reasonably foreseeable future projects or activities to terrestrial wildlife health are considered not significant. The confidence level ascribed to cumulative terrestrial wildlife health risk is moderate;
- The residual cumulative effects of the Project in combination with those of other past, present, and reasonably foreseeable future projects or activities during Operations (and by inference other less influential Project phases) to aquatic wildlife health are considered not significant. The confidence level ascribed to cumulative aquatic wildlife health risk is moderate; and
- The residual cumulative effects of the Project in combination with those of other past, present, and reasonably foreseeable future projects or activities during Operations (and by inference other less influential Project phases) to human health are considered not significant. The confidence level ascribed to human health risk is “high”.

The results of the cumulative effects assessment indicate that there are no significant residual cumulative effects to ecological or human health anticipated because of the Project in combination with other past, present, and reasonably foreseeable future projects or activities.

Monitoring the influence of the proposed Project on environmental quality to validate the health effects assessment is appropriate; however, no specific follow-up activities are required beyond those previously defined. Planned follow-up monitoring requirements associated with potential changes to the biophysical environment, as described in other chapters of the Application/EIS are suitable inputs to revisit the predictions of the HHERA and its associated models. Biophysical monitoring of surface water, sediment, air quality and possibly plant/animal tissue can be used as inputs to the multimedia food web and exposure model to validate the outputs of the HHERA (i.e., risk estimates) and identify whether additional risk management actions are necessary.

22.9 References

A condensed list of important references used in the conduct of the HHERA is provided below. For a complete list of references, refer to the Detailed Quantitative Environmental Risk Assessment in Appendix 22-A.

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