Section 6.12
Environmental Health

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6.12 Environmental Health

This section assesses the potential effects and risks to humans and other organisms that may be exposed to chemicals of potential concern (COPCs) associated with the proposed Kitsault Mine Project (proposed Project. Mining projects often have high metals concentrations; in addition, volumes in mining wastes and dust generated from mining activities can often persist in the environment. In addition, metals can also pose the most potential for chronic health risks at mines due to their effects on human and non-human health. In addition, The environmental health component of the proponent's Application for an Environmental Assessment Certificate pursuant to the *Environmental Assessment Act* (Application) integrates predicted environmental effects data presented in other sections of the Application, and examines potential adverse impacts to the health of people and other organisms from potential cumulative exposure to COPCs in all environmental media. The assessment also quantifies and prioritises potential carcinogenic and non-carcinogenic health effects in accordance with risk assessment methodologies from HC, EC, and the BC MOE.

The environmental health assessment utilises information from each of the EA disciplines to identify potential receptors as the basis for determining exposure risk. The risk assessment assumes that there is a relationship between the health of people and the health of the surrounding land. This view is based on an understanding that health depends on the surrounding environment, particularly biophysical components such as air, soil, vegetation, water, fish, and wildlife. Any release of chemicals that affect environmental health may have implications for human health.

6.12.1 Valued Component Scoping and Rationale

The valued components assessed previously in sections 6.2 through 6.11 of this Application have identified potential Project-related direct and indirect effects including POHCs, and have presented mitigation measures to minimise or eliminate their predicted effects. The environmental health section has adopted these VCs based upon the rational presented in the other sections as representative receptors for the assessment of potential effects of COPCs from the proposed Project. It was assumed that each of the VCs (i.e. receptors) could be exposed to the POHCs via recognized exposure pathways of inhalation, ingestion and direct contact. Potential effects would be determined using chemical analyses and exposure modelling results to determine the potential for the occurrence of effects of the proposed Project on human health and/or an associated non-human organism. The results of the assessment are presented as a risk characterisation that combines the results for exposure and toxicity assessment for each COPC to determine if the predicted risk is acceptable and/or unacceptable for each of evaluated COPCs. For the human VC scenarios these results are presented as potential carcinogenic or non-carcinogenic effects. For the non-human receptors discussed in this section the exposure assessment are presented as a predicted threshold level of the COPC in the organism that has been shown to have an effect such as diminished growth or fewer offspring. Additional detail and explanation of the environmental health assessment process described in the balance of this section is described in the Baseline Appendix 6-12-A.

The potential exposure pathways for the non-human organism's assessment (proposed Project VCs) have been grouped in accordance with the the way that they may be exposed to contaminated media:

(1) aquatic receptors directly exposed to contaminants in surface water and / or sediment;

(2) wildlife exposed to contaminants via ingestion of surface water / sediment, direct soil contact, and food items; and

(3) terrestrial plants and soil invertebrates exposed by direct contact with the soil.

Finally, as possible where data were available the RA predicts potential effects on those VCs selected to represent major ecosystem components as discussed in other sections for mammals, birds, amphibians, fish, invertebrates (soil, aquatic); and plants (terrestrial, aquatic).

The assessment focuses on the COPCs, receptors, and exposure pathways of greatest concern and defines the scope of the assessment to maintain the environmental health risk within practical boundaries. Chemicals, receptors, and exposure pathways of concern are first identified then screened for relevance and potential requirement for further quantitative analysis.

Considerations in the environmental risk assessment included the fate and behavior of the chemicals in the environment, and the potential toxicological potency based on various exposure pathways (i.e., air, water, soil, and food) and routes of exposure (i.e., inhalation, ingestion, and dermal) to the human or ecological receptor. The assessment utilizes the results of the quantitative risk assessment presented in the baseline (Appendix 6.12-A) that predicted risk to COPCs from exposure to soil, water, and ingestion of country foods. Air emissions data as an air/inhalation exposure pathway was not available for the assessment for the following reasons as summarised from section 6.2 (Atmospheric Environment). "The emissions inventory for the proposed Project shows that approximately 95% of crustal particulate matter emissions originate from haul truck wheel entrainment (75%) and from material deposited by the conveyor (25%, see air quality model description in Appendix 6.2-C). As described above, the greatest fugitive dust deposition rates are expected to occur close to haul and access roads and adjacent to ore stockpiles. The ore stockpiles for the proposed Project will be located well within the foot-print of the proposed mine site. Therefore, assessment of potential effects of fugitive dust deposition will focus on areas adjacent to haul roads." As a result the pathways utilised as the basis for the environmental health assessment assumes receptor exposure to COPCs via interaction with soil, water and plant materials.

The procedures to complete an HHRA and ERA consist of the same four main steps:

1. **Problem formulation**: The three key elements of risk (receptors, COPC, and exposure pathways) are identified to determine qualitatively whether or not a potential risk exists at the site.
2. **Toxicity assessment**: Dose-response information for each COPC is reviewed and the acceptable doses each receptor may receive are estimated.
3. **Exposure assessment**: The potential exposure dose of each COPC that each receptor could receive from each complete exposure pathway is estimated. An exposure dose is a function of the COPC concentration in various environmental media, biological, and life characteristics of the receptor, and chemical-specific parameters that influence COPC absorption.
4. **Risk characterisation**: The results of the toxicity assessment are integrated with the results of the exposure assessment to provide a quantitative assessment of health risk.

This shared risk assessment approach progresses from a more qualitative first phase (problem formulation) through exposure and toxicity analysis, and culminates in a final quantitative risk characterisation. Based on the risk characterisation, baseline human and / or ecological health can then be assessed based on the magnitude of the predicted risk, the degree of uncertainty, and the potential consequences to environmental health.

The problem formulation step of a risk assessment determines qualitatively whether or not a potential risk may exist, and involves identifying the three key elements of risk: COPCs; receptors; and exposure pathways via which a receptor could be exposed to COPC. If any one of these three key elements of risk is missing, there can be no risk. The baseline PQRA and ERA assumed that exposure pathways could be soil or water and routes of exposure via food, water and dermal contact. As an environmental health assessment the scope of the assessment would attempt to account for potential exposures to (receptors) that are the identified VCs for the proposed Project including humans as follows:

- Humans (Section 10.0, Human Health): toddlers (non-carcinogenic health risks) and adults (carcinogenic health risks);
- Mammals (Section 6.11, Wildlife): large carnivore/omnivores, ungulates (large herbivores), furbearers (small carnivores and small herbivores);
- Birds (Section 6.11, Wildlife): raptors, songbirds, terrestrial birds, waterfowl and shorebirds;
- Amphibians (Section 6.11, Wildlife);
- Fish (Section 6.7, Fisheries);
- Invertebrates: soil and aquatic; and
- Plants (Section 6.10, Vegetation): terrestrial and aquatic.

A receptor is defined as an organism or group of organisms that have the potential to be affected by a chemical or other stressors. Receptors selected for assessment are the Valued Components (VCs) that have been identified in other sections of this Application. The VCs are defined as resources or environmental features that are important to human populations, have economic and / or social value, or have intrinsic ecological significance. The VCs have local, regional, provincial, national, and / or international profiles, and serve as baseline components from which the effects of development can be evaluated, including changes made to management or regulatory policies. The receptors or VCs for which health risks were assessed include any organisms (i.e., human or ecological) that could be present in the vicinity of the proposed Project throughout its life.

A worst-case scenario risk assessment was then conducted using the most conservative information available from each of the disciplines. If risks are acceptable for the worst-case scenario, then risks for all other scenarios will also be acceptable. Risk assessment calculations focus on the exposure of a hypothetical individual that is maximally exposed to a COPC within a defined geographic area. In reality, not all members of a population would experience the same level of exposure, and hypothetical changes in individual health would not necessarily manifest themselves as changes in individual or population health. Finally, given the location of the proposed Project it is highly unlikely that the assumed receptors could be exposed to the POHCs under the conditions described every day for an entire lifetime. The assessment provides information intended to assist the assessor to identify potential risks to human and ecological receptors at the community or population level.

6.12.1.1 Human Receptors

The exposure scenario must include certain assumptions for the receptor to interact with COPCs. For the Human receptors the assumption is the form of permanent habitation in the vicinity of the proposed Project. This would include members of the Nisg̲a'a Nation, Aboriginal groups, and other local community populations. These potential receptors could be undertaking various recreational, hunting, or other subsistence-gathering activities, or occupying a residence (permanent or temporary) within the vicinity of the proposed Project. It is assumed that people who meet the above-described criteria could be potentially exposed to COPCs via:

- Ingestion of food, water, and soil;
- Inhalation of dust from re-suspended soil; and
- Dermal contact with soil.

The assessment of risk as indicated requires the opportunity for the potential receptor to be exposed to the proposed Project and its potential COPCs. The assumption utilised for the HHRA was that any individuals who could be in the proposed Project vicinity at any point throughout the life of the proposed Project could be at risk of experiencing adverse health effects. These potential receptors were assumed to include potential future residents and transient visitors participating in activities such as hunting, trapping, and fishing.

Although there is a limited amount of human habitation in the area, it was conservatively assumed that there is permanent occupancy in the vicinity of the proposed Project area. It was assumed that the proposed receptors are occupying their residence (i.e. a cabin) located in the area. Consultation information gathered by the proponent confirms that there are no permanent residences other than at the Kitsault or Alice Arms communities; however this conservative assumption satisfies the requirements for exposure conditions needed for the risk assessment.

Because of the unrestricted access throughout the region, it was also assumed that potential receptors could include all age groups (as defined by Health Canada (HC) 2007a), including infants (0 - 6 months), toddlers (7 months - 4 years), children (5 years - 11 years), teens (12 years - 19 years), and adults (20+ years). Depending on age, lifestyle, and genetic and environmental factors, it is also recognised that these different individuals would potentially assimilate chemicals into their bodies, and would subsequently experience various ranges of adverse health effects to the assumed exposures.

This risk assessment focuses on the toddler receptor for non-carcinogenic effects and the adult receptor for carcinogenic effects. Health risks from non-carcinogenic COPCs were evaluated using toddler characteristics because toddlers ingest more soil and water per unit body mass and have higher rates of hand-to-mouth activities. This risk assessment describes an extremely conservative scenario as it is recognized that toddlers would not be expected to be in the vicinity of the proposed Project during its operations phase, and would also not be expected to access the proposed Project site at closure, and thus would not be participating in activities that could lead to ingestion of soil.

For the carcinogenic risk assessment, the receptors of concern are adult receptors because they experience the longest exposure duration (i.e. potentially the longest time living in the area) and this contributes to the long latency period for the development of cancers. Therefore, the cancer risk assessment evaluated the risks for just the adult phase (HC 2007a).

To account for this uncertainty, health risks were evaluated using biological characteristics for the most conservative age class (HC 2007a). These characteristics and receptor behaviors for each age class are listed in “Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance On Human Health Preliminary Quantitative Risk Assessment” (HC 2007a) and summarised in Table 6.12.1-1.

Table 6.12.1-1: Receptor Characteristics and Activities for Exposure Modelling

Receptor Characteristic	Units	Toddler	Adult
Age		7 m – 4 yr	>20 yr
Lifespan			75 yrs
Bodyweight	kg	16.5	70.7
Inhalation Rate	m^3/day	9.3	15.8
Ingestion Rate			
water	L/day	0.6	1.5

Receptor Characteristic	Units	Toddler	Adult
soil	g/day	0.08	0.02
root vegetables	g/day	105	188
other vegetables	g/day	67	137
medicinal herbs (First Nations)[1]	g/day	1	3
berries (First Nations)[1]	g/day	5	23
fish	g/day	56	111
fish (First Nations)[1]	g/day	95	220
wild game (First Nations)[1]	g/day	85	270
Skin Surface Area			
hands	cm^2	430	890
arms (upper and lower)	cm^2	890	2500
legs (upper and lower)	cm^2	1690	5720
TOTAL	cm^2	3010	9110
Soil Loading to Exposed Skin			
hands	g/cm^2/event	1.00×10^{-4}	1.00×10^{-4}
surfaces other than hands	g/cm^2/event	1.00×10^{-5}	1.00×10^{-5}
Soil-to-skin Adherence Factor	mg/cm^2	0.1	0.1
Exposure			
time	hr/day	24	24
frequency	day/yr	365	365
Duration	yr	4.5	60
Average Time – non-carcinogens	days	1642.5	20440
Average Time – carcinogens	days	n/a	27375

Note: [1] ingestion rate for Canadian First Nations Populations

Source: HC (2007); 1 – Alberta Health and Wellness

6.12.1.2 Ecological Receptors

The receptor characterisation step in an ERA includes the characterisation of the proposed Project site with respect to the ecological habitats or resources present or likely to be present. Receptor characterisation is designed to:

1. Identify VCs (i.e., biological communities, populations, individuals, or habitats potentially at risk, including rare, threatened, or endangered species);
2. identify potential exposure pathways and routes by which ecological receptors may be exposed to chemicals in the environment; and
3. determine the appropriate assessment endpoints for the ERA.

A receptor is defined as an organism or group of organisms that have the potential to be affected by a chemical or other stressors. Receptors selected for assessment include the VCs adopted for this proposed Project, which are defined as resources or environmental features that are important to human populations, have economic and / or social value, or have intrinsic ecological significance. The VCs have local, regional, provincial, national, and / or international profiles, and serve as a baseline from which the effects of development can be evaluated, including changes in management or regulatory policies. Because it is not possible to evaluate all ecological species that may potentially be present at a site, representative receptors (VCs) were selected based on several criteria (CCME 1996a), including:

- Threatened or endangered species;
- Sensitivity to chemicals;
- Biological and ecological relevance;
- Ability to measure or predict effects; and
- Social relevance (i.e., species of recreational, commercial, or social importance).

Receptors are not always identified at the species level; rather, they can also represent major groups of receptors deemed to be important and are sometimes defined by trophic level. For example, benthic invertebrates may be identified as an important ecological component due to their role as filter feeders and prey for fish; individual species of invertebrates are not typically identified as receptors.

The exception is when at-risk (endangered or otherwise threatened) species are present. When such species are present, additional consideration should be given to providing protection at the level of the species or individual.

According to the *Species at Risk Act* (*SARA*) (Government of Canada 1992), species at risk are categorised as:

- **Extinct:** A wildlife species that no longer exists anywhere in the world;
- **Extirpated:** A wildlife species that no longer exists in the wild in Canada, but exists elsewhere;
- **Endangered:** A wildlife species that is facing imminent extirpation or extinction;
- **Threatened:** A wildlife species likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction; and
- **Special Concern:** A wildlife species that may become a threatened or endangered species because of a combination of biological characteristics and identified threats.

For the purposes of this Environmental Assessment (EA), the proponent has identified the following VCs and their potential exposure pathways as representative of the ecosystem's major components. It should be noted that the following list of species includes more species (VCs) than have been selected for some of the specific environmental disciplines. The addition of these additional species helps the environmental health assessor to demonstrate that the full range of flora and fauna that could be effected by the proposed

Project have been recognised and given suitable consideration. For some potential wildlife VCs, the umbrella species concept will be used to ensure that the needs of each species are addressed. An umbrella species is one whose distribution and habitat requirements are well known and are representative of the requirements of a wide range of co-existing species which may be lesser known and thus difficult to assess on an individual species basis. The representative species used for the purposes of this EA include:

- **Large carnivore / omnivore mammals** have been assessed as receptors and identified as a VC in the Wildlife section (Section 6.11). Rationale for their selection as a VC is provided in Section 6.11. The grizzly bear (*Ursus arctos horribilis*) was assessed as a representative species since it was assumed that if risks identified are acceptable for a typical grizzly bear, then risks would be acceptable for all large carnivorous/ omnivorous mammals. Grizzly bears may potentially be exposed to COPCs via ingestion of food sources, soil and surface water;
- **Large herbivore ungulate mammals** have been assessed as receptors and identified as a VC in the Wildlife section (Section 6.11). Rationale for their selection as a VC is provided in Section 6.11. The moose (*Alces alces*) was assessed as a representative species due to its significance to the Nisga'a Nation hunters and other hunters who frequent the region. If risks are acceptable for a typical moose, then risks would be acceptable for all large herbivorous ungulate mammals. Moose may potentially be exposed to COPCs via ingestion of food sources, soil, and surface water;
- **Small carnivore / omnivore mammals** have been assessed as receptors and are identified as a VC in the Wildlife section (Section 6.11). Rationale for their selection as a VC is provided in Section 6.11. The American marten (*Martes americana*) has been assessed as a representative species of small carnivore / furbearers because risks for this species extend to all small carnivore / omnivore mammals. If risks are acceptable for a typical American marten, then risks would be acceptable for all small carnivore / omnivore mammals. American martens may potentially be exposed to COPCs via ingestion of food sources, soil, and surface water;
- **Small herbivore mammals** have not been identified as a VC in the wildlife section(Section 6.11; however, they are considered an ecological receptor in this assessment because of their abundance in the vicinity of the proposed Project and because of their importance in the biotransfer process of COPCs along the food chain. The snowshoe hare (*Lepus americanus)* has been assessed as a representative species. Using the umbrella approach, it was assumed that if risks are acceptable for a typical snowshoe hare, then risks would be acceptable for all small herbivorous furbearing mammals. Snowshoe hares may be potentially exposed to COPCs via ingestion of food sources, soil, and surface water;
- **Birds – Raptors** have been assessed as receptors and are identified as a VC in the Wildlife section (Section 6.11). Rationale for their selection as a VC is provided in Section 6.11. The northern goshawk (*Accipiter gentilis*) has been assessed as a representative species. Using the umbrella approach, it was assumed that if risks were acceptable for a typical northern goshawk, then risks would be acceptable for

all raptors. Northern goshawks may potentially be exposed to COPCs via ingestion of food sources, soil, and surface water;

- **Birds – Songbirds** have been assed as a receptor and are identified as a VC in the Wildlife section (Section 6.11). Rationale for their selection as a VC is provided in Section 6.11. The olive-sided flycatcher (*Contopus cooperi*) has been assessed as a representative species. Using the umbrella approach, it was assumed that if risks are acceptable for a typical olive-sided flycatcher, then risks would be acceptable for all songbirds. Olive-sided flycatchers may potentially be exposed to COPCs via ingestion of food sources, soil, and surface water;
- **Birds – Terrestrial birds** have been assessed as a receptor and are identified as a VC in the Wildlife section (Section 6.11). Rationale for their selection as a VC is provided in Section 6.11. The sooty grouse (*Dendragapus fuliginosus*) has been assessed as a representative species. Using the umbrella species approach, it was assumed that if risks are acceptable for a typical sooty grouse, then risks would be acceptable for all terrestrial birds. Sooty grouse may potentially be exposed to COPCs via ingestion of food sources, soil, and surface water;
- **Birds – Waterfowl** have not been identified as a VC in the Wildlife section (Section 6.11); however; they have been assessed as an ecological receptor because of their abundance in the vicinity of the proposed Project and their importance associated with potential exposure to COPCs in aquatic environments. The common loon (*Gavia immer)* has been assessed as a representative species since it was assumed that if risks are acceptable for a typical loon, then risks would be acceptable for all waterfowl. Common loons may be potentially exposed to COPCs via ingestion of fish and surface water;
- **Birds – Shorebirds** have not been identified as a VC in the Wildlife section (Section 6.11); however; they have been assessed as an ecological receptor because of their abundance in the vicinity of the proposed Project and their importance associated with potential exposure to COPCs in aquatic environments. The spotted sandpiper (*Actitis macularia)* has been assessed as a representative species since it was assumed that if risks are acceptable for a typical spotted sandpiper, then risks would be acceptable for all shorebirds. Spotted sandpipers may be potentially exposed to COPCs via ingestion of invertebrates, sediments, and surface water;
- **Amphibians** have been assessed as receptor because they are identified as a VC in the Wildlife section (Section 6.11). Rationale for their selection as a VC is provided in Section 6.11. The Western toad (*Anaxyrus boreas)* has been assessed as a representative species; if risks are acceptable for a typical Western toad, then risks would be acceptable for all amphibians. Western toads may potentially be exposed to COPCs through dermal contact with soil and surface water;
- **Fish** have been assessed as a VC and are identified as a VC in the Freshwater and Aquatic Resources section (Section 6.7). Fish are important in the ecosystem as both predators and a food source for piscivorous birds and mammals. Dolly Varden (*Salvelinus malma)* were selected as a representative surrogate for all fish species.

It was assumed that if risks were acceptable for a typical Dolly Varden, then risks would be acceptable for all fish that could be affected by the proposed project;

- **Soil invertebrates** have been assessed as ecological receptors in order to evaluate potential adverse effects to their health through exposure to COPCs in soil. They were considered a VC because of their presence in a healthy ecosystem, as well as their ubiquity in the environment. Earthworms were selected as a representative surrogate for all soil invertebrate species. Soil invertebrates are potentially exposed to COPCs through ingestion of and direct contact with soil;
- **Aquatic invertebrates** have been assessed as ecological receptors and are an important group of organisms in most freshwater systems. Macroinvertebrates, as prey for many fish species, are critical to the proper functioning of aquatic ecosystems. Additionally, invertebrates as a group tend to be one of the most sensitive to environmental contaminants, so protection of invertebrates also tends to result in protection of other species. Invertebrates are often used as "indicators" of environmental degradation because of their rapid and predictable response to various environmental contaminants and other stressors. Metal toxicity to benthic invertebrates was not evaluated because pore water data was not available at the time of the assessment. However, aquatic invertebrates were assessed as an ecological receptor and would be potentially exposed to COPCs through direct contact with surface water;
- **Terrestrial plants** have been assessed as receptors to ensure that their health in the vicinity of the proposed Project would not be adversely affected by accumulating COPCs from soil. Certain plants in the vicinity of the proposed Project represent important country foods for local Aboriginal community populations. As autotrophs, plants are the foundation of any terrestrial ecosystem, including those heavily influenced and relied upon by humans. The type and quality of vegetative growth is the most visible indicator of forest health;
- **Aquatic plants** have been assessed as receptors to ensure that their health in the vicinity of the proposed Project would not be adversely affected by COPCs in surface water. Aquatic plants play an important role in most freshwater systems. They take a variety of forms, including submerged, emergent, and free-floating forms. Aquatic plants, including algae, oxygenate water and form the basis of the aquatic food chain. Submerged macrophytes also provide habitat / cover for a variety of fish. Emergent forms, such as cattails, bullrushes, and reeds, are used by birds for cover and food. Plants are not especially sensitive to bioaccumulative substances, but are sensitive to toxicity from some metals. Aquatic plants were evaluated as a group rather than on an individual species basis; and
- **Species not assessed** – Other species or groups of organisms not selected as VCs may also inhabit the proposed Project site, and are potentially exposed to COPCs. However, given the number of species potentially present in the area, it is neither practical nor appropriate to consider all species. Only those species likely to be exposed to contaminants, those which are important components of the ecosystem,

those which represent a wide variety of similar species, and those which possess social value have been considered.

6.12.1.3 Valued Component / Issue Identification and Scoping

The issues relevant to the environmental health component included the COPCs associated with the proposed Project that could adversely affect the long-term health of human and ecological organisms. Emphasis was placed on identifying the metal COPCs, as metals usually pose the most potential for chronic health risks at mines due to their concentrations and volumes in mining wastes, and their persistence in the environment. This potential for increased health risks for metals is present within the mine footprint; however, the potential health risk from exposure to metals decreases outside of the mine footprint. Table 6.12.1-2 presents an interaction matrix for environmental health. The type of interactions expected between the proposed Project component and environmental health VCs are presented using the following symbols:

- o to indicate that there is an interaction;
- - to indicate a key interaction; and
- + to indicate a benefit.

These interactions are described in more detail for each of the proposed Project phases in Tables 6.12.1-2 to 6.12.1-5.

Table 6.12.1-2: Valued Component / Issue Interaction Matrix for Environmental Health

Project Phase	Humans	Mammals	Birds	Amphibians	Fish	Soil Invertebrates	Aquatic Invertebrates	Terrestrial Plants	Aquatic Plants
Construction Phase									
Existing access road	o	o	o	-	-	-	-	-	-
Equipment and machinery transportation to site including analysis of anticipated changes to traffic (e.g., type and volume) of public roads	o	o	o	-	-	-	-	-	-
Emissions and dust generation (fugitive emissions, equipment operation and movement)	-	-	-	-	-	-	-	-	-
Land clearing	o	o	o	-		-		-	
Excavating	o	o	o	-		-		-	
Grading	o	o	o	-		-		-	
Soil and till salvage, handling and storage, including	o	o	o	-		-		-	

Project Phase	Humans	Mammals	Birds	Amphibians	Fish	Soil Invertebrates	Aquatic Invertebrates	Terrestrial Plants	Aquatic Plants
locations, volumes and affected areas									
Mine infrastructure installations									
Kitsault Pit development									
Process plant and ancillary facilities									
Borrow sources									
Expansion of exploration camp to create construction and permanent camps									
Waste Rock Management Facility (WRMF) development									
Tailings Management Facility (TMF) development									
Blasting									
Operation Phase									
Existing access road									
Erosion control	-	-	-	-	-	-	-	-	-
Emissions and dust generation (fugitive dust, equipment operation and movement)	-	-	-	-	-	-	-	-	-
Soil and till salvage, handling and storage, including locations, volumes and affected areas	o	o	o	o		o		o	
Kitsault Pit Mining	o								
Transportation of concentrate by truck	o	o	o	o	o	o	o	o	o
Processing	o	o	o	o	o	o	o	o	o
WRMF development									
TMF development	o	o	o	o	o	o	o	o	o
Blasting									
Management of overburden stockpiles and waste rock dumps supported by relevant geotechnical data and stability analysis									
Waste water management and treatment plant		o	o	-	-		-		-
Decommissioning and Closure Phase									

Project Phase	Humans	Mammals	Birds	Amphibians	Fish	Soil Invertebrates	Aquatic Invertebrates	Terrestrial Plants	Aquatic Plants
Access and mine access road decommissioning and reclamation									
Equipment and machinery removal, recycling and disposal									
Erosion control	-	-	-	-	-	-	-	-	-
Emissions and dust generation (equipment operation and movement)	-	-	-	-	-	-	-	-	-
Revegetation									
WRMF area reclamation									
TMF area reclamation									
Molybdenum concentrate stockpile areas reclamation and fugitive dust control									
Post-Closure Phase									
Monitoring and maintenance of terrain stability									
Monitoring and maintenance of soil stability and vegetation									
Monitoring and maintenance of habitat compensation areas.									

Note: TMF - Tailings Management Facility; WRMF - Waste Rock Management Facility

Legend: o - interaction; - - key interaction;□□□ + - benefit

Table 6.12.1-3 presents interactions between potential Project components and VCs during the construction phase of the proposed Project.

Table 6.12.1-3: Potential Issues by Project Component and Valued Component – Construction Phase

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
Exiting access road	Increases potential exposure to COPCs released in air, soil and country foods	Humans, mammals, birds, amphibians, fish, soil and aquatic invertebrates, and terrestrial and aquatic plants	Vehicle noise, emissions and increase in dust
Equipment and	Increases potential	Humans, mammals,	Vehicle noise,

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
machinery transportation to site including analysis of anticipated changes to traffic (e.g., type and volume) of public roads	exposure to COPCs released in air, soil and country foods	birds, amphibians, fish, soil and aquatic invertebrates, and terrestrial and aquatic plants	emissions and increase in dust
Emissions and dust generation (fugitive emissions, equipment operation and movement)	Increases potential exposure to COPCs released in air, soil, surface water and country foods	Humans, mammals, birds, amphibians, fish, soil and aquatic invertebrates, and terrestrial and aquatic plants	Exposure to release of COPCs in the emissions and fugitive dust that can migrate through various environmental media pathways and may adversely affect the health of human and ecological receptors (e.g., ingestion, direct contact, inhalation)
Soil and till salvage, handling and storage, including locations, volumes and affected areas	Increases potential exposure to COPCs released in air, soil and country foods	Humans, mammals, birds, amphibians, soil invertebrates and terrestrial plants	Exposure to COPCs in the soil may migrate and adversely affecting the health of human and ecological receptors (e.g., ingestion, direct contact, inhalation)

Note: COPC - Chemical of Potential Concern

Table 6.12.1-4 presents interactions between potential Project components and VCs during the operations phase of the proposed Project.

Table 6.12.1-4: Potential Issues by Project Component and Valued Component – Operations Phase

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
Emissions and dust generation (fugitive dust, equipment operation and movement)	Increases potential exposure to COPCs released in air, soil, surface water and country foods	Humans, mammals, birds, amphibians, fish, soil and aquatic invertebrates, and terrestrial and aquatic plants	Exposure to COPCs in the emissions and fugitive dust can migrate through various environmental media pathways and may adversely affect the health of human and ecological receptors (e.g., ingestion, direct contact, inhalation)
Soil and till salvage, handling and storage, including locations, volumes and affected areas	Increases potential exposure to COPCs released in air, soil and country foods	Humans, mammals, birds, amphibians, soil invertebrates and terrestrial plants	Exposure to COPCs in the soil may adversely affect the health of human and ecological receptors (e.g., ingestion, direct contact, inhalation)
Kitsault Pit Mining	Increase potential exposure to COPCs released in air and soil during pit mining activities	Humans, mammals, birds, soil invertebrates and terrestrial plants	Exposure to COPCs through air and soil exposure pathways may adversely affect the health of human receptors and ecological receptors (e.g., ingestion, direct contact, inhalation)
Transportation of concentrate by truck	Increases potential exposure to COPCs released in air, soil, surface water and country foods from the accidental spill / release scenario of concentrate during the transportation by truck	Humans, mammals, birds, amphibians, soil invertebrates and terrestrial plants	Exposure to COPCs through various environmental media may adversely affect the health of human and ecological receptors (e.g., ingestion, direct contact, inhalation)
Processing	Increase in potential exposure to COPCs in air, soil, surface water and country foods from emissions and effluent released during processing activities.	Humans, mammals, birds, amphibians, fish, soil and aquatic invertebrates, and terrestrial and aquatic plants	Exposure to COPCs in various environmental media and exposure pathways may adversely affect the health of human and ecological receptors (e.g., ingestion, direct contact, inhalation)
TMF development	Exposure to COPCs in surface water from	Humans, mammals, birds, amphibians, fish,	Exposure to COPCs in various environmental

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
	effluent release	soil and aquatic invertebrates, and terrestrial and aquatic plants	media and through various exposure pathways may adversely affect the health of human and ecological receptors (e.g., ingestion, direct contact)
Waste water management and treatment plant	Exposure to COPCs in surface water	Amphibians, fish, aquatic invertebrates and aquatic plants	Exposure to COPCs in the surface water may adversely affect the health of aquatic ecological receptors (e.g., direct contact)

Note: COPC - Chemical of Potential Concern; TMF - Tailings Management Facility

Table 6.12.1-5 presents interactions between potential Project components and VCs during the closure and decommissioning phase of the proposed Project.

Table 6.12.1-5: Potential Issues by Project Component and Valued Component – Closure and Decommissioning Phase

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
Emissions and dust generation (fugitive dust, equipment operation and movement)	Exposure to COPCs in air, soil, surface water and country foods	Humans, mammals, birds, amphibians, fish, soil and aquatic invertebrates, and terrestrial and aquatic plants	Exposure to COPCs in the various environmental media and exposure pathways may adversely affect the health of human and ecological receptors (e.g., ingestion, direct contact, inhalation)

Note: COPC - Chemical of Potential Concern

Potential Project components during the post-closure monitoring phase of the proposed Project are not expected to affect the human and ecological VCs.

6.12.1.4 Valued Component / Issues Confirmation

The VCs selected as potential receptors for the assessment of environmental health risk are based on the assumption that activities occurring during all phases of the proposed Project could have an effect on an identified VC. Many of the potential effects act as pathways to other components and are considered here as VCs in order to ascertain the validity of the connection throughout the proposed Project lifespan. Table 6.12.1-6 presents the confirmation for VC inclusion and selection rationale for the environmental health discipline.

The assessment utilizes a conservative approach and presents the exposure predictions in scenarios that need to be put into context for the proposed project including the following:

- Although arsenic is a COPC it would be highly unlikely for an adult to be consistently exposed to the utilized concentrations every day of their entire life
- The size of the regional study area is such that it would be unlikely that an individual would spend an entire lifetime at one receptor location.

Table 6.12.1-6: Environmental Health Valued Component Selection Rationale

Valued Component	Rationale							
	Interaction with Proposed Project Activities	**Scientific Literature and Professional Judgement**	**Nisga'a Lisims Government**	**Aboriginal Groups included by BC EAO**	**Applicable Government Agencies**	**Land and Resource Management Plans**	**The Public and Other Stakeholders**	**Federal and Provincial Regulations and Guidelines**
Humans (toddlers and adults)	Exposure to COPCs in various environmental media may adversely affect the health of humans (e.g., ingestion, direct contact, inhalation)	Identified by AMEC and the proponent	Human health is valued by Nisga'a Nation citizens	Human health is valued by other Aboriginal Groups	BC MOE, HC, EC, CCME	Central and North Coast EBM	Human health is valued by the public, NGOs, and industry	Human Health Risk Assessment guidance materials; BC MOE 1993, , 2007; HC 2007; CCME 1996.
Mammals (large and small carnivores / omnivores, ungulates and furbearers)	Exposure to COPCs in various environmental media may adversely affect the health of mammals (e.g., ingestion)	Identified by AMEC and the proponent	Known to be important to Nisga'a Nation citizens	Selected by BC EAO Working Group	BC MOE, EC, CCME, CWS and CWF	Central and North Coast EBM	Ecological health is valued by the public, NGOs, and industry	Ecological Risk Assessment guidance materials: BC MOE 1997, 1998a, 2007; CCME 1996, 1997; CWS and CWF 2008b
Birds (raptors, songbirds, terrestrial birds, waterfowl and shorebirds)	Exposure to COPCs in various environmental media may adversely affect the health of birds (e.g., ingestion)	Identified by AMEC and the proponent	Known to be important to Nisga'a Nation citizens	Selected by BC EAO Working Group	BC MOE, EC, CCME, CWS and CWF	Central and North Coast EBM	Ecological health is valued by the public, NGOs, and industry	Ecological Risk Assessment guidance materials: BC MOE 1997, 1998a, 2007; CCME 1996, 1997; CWS and CWF 2008a

Valued Component	Rationale							
	Interaction with Proposed Project Activities	Scientific Literature and Professional Judgement	Nisg̲a'a Lisims Government	Aboriginal Groups included by BC EAO	Applicable Government Agencies	Land and Resource Management Plans	The Public and Other Stakeholders	Federal and Provincial Regulations and Guidelines
Amphibians	Exposure to COPCs in surface water may adversely affect the health of amphibians (e.g., direct contact)	Identified by AMEC and the proponent	Known to be important to Nisg̲a'a Nation citizens	Selected by BC EAO Working Group	BC MOE, EC, CCME	Central and North Coast EBM	Ecological health is valued by the public, NGOs, and industry	Ecological Risk Assessment guidance materials: BC MOE 1997, 1998a, 2007; CCME 1996, 1997
Fish (Dolly Varden)	Exposure to COPCs in surface water may adversely affect the health of fish (e.g., direct contact)	Identified by AMEC and the proponent	Known to be important to Nisg̲a'a Nation citizens	Selected by BC EAO Working Group	BC MOE, EC, CCME	Central and North Coast EBM	Ecological health is valued by the public, NGOs, and industry	Ecological Risk Assessment guidance materials: BC MOE 1997, 1998a, 2007; CCME 1996, 1997
Invertebrates (soil and aquatic)	Exposure to COPCs in soil, sediment, and water can adversely affect the health of invertebrates (e.g., direct contact)	Identified by AMEC and the proponent	Known to be important to Nisg̲a'a Nation citizens	Selected by BC EAO Working Group	BC MOE, EC, CCME	Central and North Coast EBM	Ecological health is valued by the public, NGOs, and industry	Ecological Risk Assessment guidance materials: BC MOE 1997, 1998a, 2007; CCME 1996, 1997

Valued Component	Rationale							
	Interaction with Proposed Project Activities	**Scientific Literature and Professional Judgement**	**Nisg̲a'a Lisims Government**	**Aboriginal Groups included by BC EAO**	**Applicable Government Agencies**	**Land and Resource Management Plans**	**The Public and Other Stakeholders**	**Federal and Provincial Regulations and Guidelines**
Plants (terrestrial and aquatic)	Exposure to COPCs in soil and water can adversely affect the health of plants (e.g., direct contact)	Identified by AMEC and the proponent	Known to be important to Nisg̲a'a Nation citizens	Selected by BC EAO Working Group	BC MOE, EC, CCME	Central and North Coast EBM	Ecological health is valued by the public, NGOs, and industry	Ecological Risk Assessment guidance materials: BC MOE 1997, 1998a, 2007; CCME 1996, 1997

Note: BC EAO - British Columbia Environmental Assessment Office; BC MOE - British Columbia Ministry of Environment; CCME - Canadian Council of Ministers of the Environment; CWF - Canadian Wildlife Federation; CWS - Canadian Wildlife Service; COPC - Chemical of Potential Concern; EC - Environment Canada; HC - Health Canada; EBM - Ecosystem-Based Management; NGO - Non-Government Organisation

6.12.2 VC #1: Humans

6.12.2.1 Introduction

In response to concerns over the potential risk to human receptors as a result of exposure to COPCs in soil, surface water, and country foods, the proponent evaluated the potential risk pathways and exposure potential within the proposed Project footprint, where COPCs were identified or anticipated . Air dispersion modelling for COPC concentrations in the vicinity of the proposed Project was not completed; therefore, the air exposure pathway was excluded from this assessment. HHRA includes the consideration of both toxic properties of chemicals associated with or released into the environment, and the degree to which people could be exposed to those chemicals.

An adult and toddler have been selected as the representative receptors for VC #1 as they could be adversely affected by COPCs introduced or mobilised in the environment as a result of the proposed Project. The HHRA involved assumptions regarding the exposure regimes that the human receptors experience. The human receptors are assumed to be Aboriginal people residing in the region engaged hunting, gathering, fishing, and / or hiking in the vicinity of the proposed Project. After one identifies the receptor at the site that would be exposed to COPCs, the method by which the receptor would be exposed to the COPCs (i.e., the source to receptor pathway) must then be identified. Pathways were considered to be complete when there was a potential for the receptor to be exposed to the COPCs. Incomplete pathways represent situations where exposure or contact with the COPCs was unlikely to occur and therefore posed no risk to the receptor. The potential exposure pathways that were considered complete for human receptors and were thus included in the exposure assessment have been identified as:

- Direct contact with soil (ingestion and dermal contact);
- Inhalation of dust;
- Ingestion of surface water;
- Ingestion of traditional plant foods (berries, roots, and leaves);
- Ingestion of wild game; and
- Ingestion of fish.

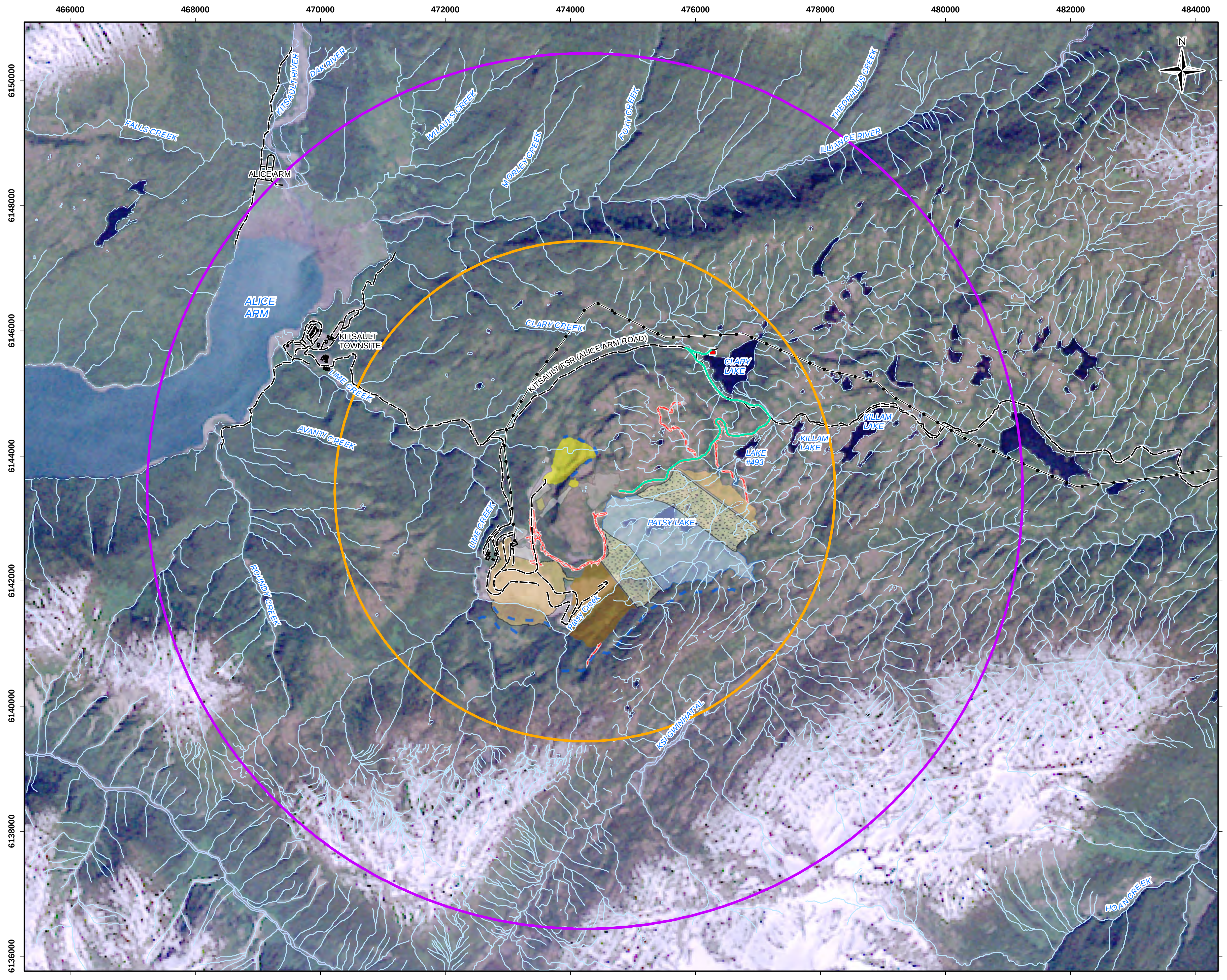
Soil, vegetation, surface water, wild game, and fish exposure pathways were evaluated to characterise the potential concentrations of COPCs in the exposure media in the vicinity of the proposed Project. For the effects assessment, surface water data for the construction and operations phases were available and were applied as a conservative approach to the HHRA model as presented Appendix 6.12-A and B of this EA section. For the remaining exposure pathways (i.e., soil, vegetation and fish), only baseline data were available and were applied to the HHRA model.

6.12.2.1.1 Relevant Legislation and Legal Framework

The HHRA was based on the prescriptive protocols outlined by the Canadian Council of Ministers of the Environment (CCME) (1996), Health Canada (HC) (2007a; 2007b), and British Columbia Ministry of the Environment (BC MOE) (1993; 2007). HC (2007a) has established a four-step paradigm for conducting health-based risk assessments. This paradigm has been adopted by federal and provincial health and environmental agencies, including BC MOE.

6.12.2.1.2 Spatial Boundaries

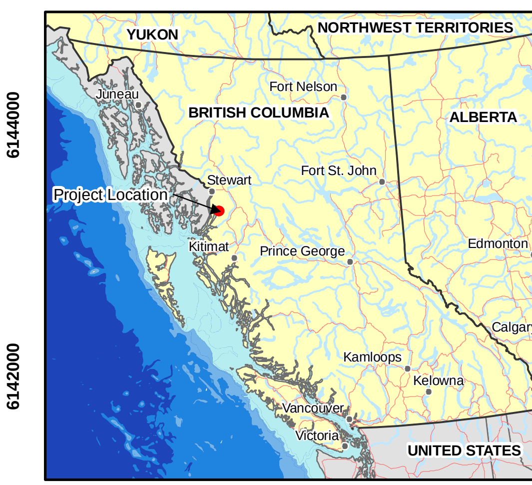
The Local Study Area (LSA) and Regional Study Area (RSA) are based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range, and activities that would bring the receptor into contact with various environmental media. In any population of organisms, there is extensive variability among individuals for each of these parameters. For human receptors, the LSA and RSA would be similar to that of the air quality study areas. The air quality discipline (Section 6.2) defines the LSA as 2 kilometres (km) wide surrounding the proposed Project footprint and the RSA as 2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).



Legend

- Access Road
- Mine Site Road
- Transmission Line
- Stream
- Waterbody
- Diversion Ditch
- Clary Lake Freshwater Pipeline
- Clary Lake Freshwater Intake
- Process Plant
- Open Pit
- Ore Stockpile
- Topsoil Stockpiles
- Waste Rock Management Facility
- Tailings Beach
- Tailings Management Facility (TMF) Supernatant Pond
- Local Study Area
- Regional Study Area

KEY MAP



Scale:1:60,000

0 0.5 1 2

Kilometres

Reference

1. Base Data
Geobase 1:20,000 (TRIM)
Land and Resource Data Warehouse 1:20,000 (TRIM)
Image: Orthophoto 40cm
2. Project Infrastructure
Supplied by AMEC and Knight Piesold on March 2011

CLIENT: AVANTI MINING INC — Avanti Kitsault Mine Ltd.

PROJECT: Kitsault Mine Project

Local and Regional Study Areas for Environmental Health

DATE: November 2011	ANALYST: MY	**Figure** 6.12.2-1	
JOB No: VE51988	QA/QC: TT	PDF FILE: 18-50-004_study_area.pdf	
GIS FILE: 18-50-004.mxd		amec	
PROJECTION: UTM Zone 9	DATUM: NAD83		

Y:\GIS\Projects\VE\VE51988_Kitsault\Mapping\18_Environmental-health\18-50-004.mxd

6.12.2.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project, which are contingent on permitting, include four primary phases:

1. Construction Phase – estimated 25-month period. This includes:
   - Site clearing and preparation, earthworks such as excavating and site grading;
   - Construction of mine site roads and power distribution lines on the site;
   - Facilities, such as processing plant, Tailings Management Facility (TMF) starter embankment, reclaim pipe works;
   - Camp complex; and
   - May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).
2. Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years would be spent milling low-grade ore). This includes progressive reclamation.
3. Decommissioning and Closure Phase – estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase – estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse effects on local receiving waters. Stabilisation of the Waste Rock Management Facility (WRMF) and TMF will also be considered in post-closure monitoring.

6.12.2.2 Information Sources and Methods

Environmental chemistry data was obtained from other disciplines (i.e., water, air, soil, and vegetation) as necessary and compared to federal and provincial regulatory guidelines. Analytical chemistry data for soil and surface water was assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health" (CCME 2011), assuming a residential / parkland land use;
- British Columbia *Contaminated Sites Regulation* (*BCCSR*) of the British Columbia *Environmental Management Act (*BC *EMA)*, Schedule 4 Generic Numerical Soil Standards (Government of British Columbia (BC) 1997), for park and residential use;
- BC "Water Quality Guidelines" (Government of BC 2011); and

- “Guidelines for Drinking Water Quality” (HC 2011).

Health risks were assessed by following Human Health Risk Assessment guidance materials recommended by the BC MOE, CCME, and HC (BC MOE 1993, 2007; CCME 1996a; HC 2007a).

In order to evaluate the overall exposure of the human receptors to project-related emissions, mathematical models were used to predict changes in the COPC concentration in the different media from baseline conditions. The chemical composition of the surface waters in rivers and creeks forming the watershed in the vicinity of the proposed mine site can mainly be altered as a result of the surface run-off of chemicals from the site through drainage ditches or from the process-water outfall into any given water body. Chemicals in the surface water can be found in either the dissolved or suspended solid state. Atmospheric depositions can also add to the increase in COPC concentration in water bodies but its overall contribution is much smaller than direct intake from discharge sites or site run-off.

The situation is different for soil and vegetation,. Atmospheric depositions (wet and dry) from project emissions are the only source of COPCs that can modify the soil chemical composition. Vegetation is affected by airborne emissions both through direct deposition and indirectly via uptake of deposited chemicals from the soil. For the Kitsault mine project, fugitive dust deposition modeling states that dust deposition along the haul road would be approximately 2.1 g/m^2/month five metres from the road, decreasing to 0.004 g/m^2/month within the LSA. These dust fall estimates are well below BC MOE objective of 8.7 g/m^2/month. Therefore, based on the anticipated minimal atmospheric deposition, it is not expected that COPCs concentration in soil and vegetation surrounding the proposed mine site will be affected during the project phase.

6.12.2.3 Description of VC #1: Humans

The Environmental Health Baseline Report (Appendix 6.12-A) discusses the results of a PQRA undertaken to assess potential human and environmental health risks from the proposed Project. Information presented in the baseline follows an accepted approach adopted in evaluating the potential impacts to human health that is consistent with the approach recommended by Health Canada (2007a). The PQRA addresses potential risks to human and non-human receptors present at the proposed Project site through relevant exposure pathways as a result of potential exposure to identified impacts in soil, surface water, and country foods based on available historical and current site data.

The human health assessment assumes that the that the primary exposure scenarios would be an exposure of a receptor to non-carcinogenic and carcinogenic chemicals. The non-carcinogenic exposure assessment involves a toddler who spends all of its time in the region and be exposed via direct contact with soil, inhalation of dust, and ingestion of soil, surface water, vegetation, blueberries, meat from wild game, and fish. Similarly the exposure for carcinogenic chemicals was assumed to be an adult who spends the same amount of time in the region and be exposed via direct contact with soil, inhalation of dust, and ingestion of soil, surface water, vegetation, blueberries, meat from wild game, and fish.

The baseline prediction was completed using site soils and water quality data as a conservative representation of site conditions. The 95th percentile concentration of soils, surface water, vegetation, wildlife, and fish data were used in this assessment. Use of the 95th percentile describes the use of a concentration that is 95% of the maximum concentration sampled or modelled. The baseline data are to be compared to the effects assessment that relied on water quality data modelled for the construction, operations, and decommissioning activities. The potential exposure scenarios of the PQRA were conservatively based on the assumption that a receptor would live in the LSA for 24 hours a day, 7 days a week, and 365 days a year for 60 years. In the exposure scenarios, the receptor would be exposed to the 95th percentile of COPC concentrations in soil, water, fish and country foods every day. It was under these conservative assumptions that the potential carcinogenic ILCR associated with baseline exposure of receptors identified for the proposed Project has been rated unacceptable for arsenic based on BC's target risk level of 10^{-5} (HC 2007). It was also concluded that the ILCR for all other carcinogens were below HC's target risk level of 10^{-5}.

Tables 6.12.2-1 and 6.12.2-2 presents the baseline assessment findings for non-carcinogenic and carcinogenic risks to humans as a potential effect of the proposed Project.

Table 6.12.2-1: Summary of Risks in Humans – Non-Carcinogenic

Metal COPC	HQ								Total HQ
	Soil			Surface Water	Plant	Berries	Wild Game	Fish	
	Ingestion	Dermal	Inhalation	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	
Arsenic	$4.5x10^{-1}$	$1.2\ x10^{-2}$	$1.5x10^{-3}$	$5.4x10^{-2}$	$8.8x10^{-4}$	$8.8x10^{-3}$	$3.5x10^{-3}$	$4.4x10^{-1}$	$9.6x10^{-1}$
Chromium	$6.1x10^{-3}$	$4.0x10^{-2}$	$7.4x10^{-4}$	$1.2x10^{-4}$	$2.0x10^{-4}$	$2.0x10^{-3}$	$3.8x10^{-4}$	$2.5x10^{-2}$	$7.5x10^{-2}$
Molybdenum	$2.0x10^{-2}$	$1.7x10^{-4}$	$1.4x10^{-5}$	$5.1x10^{-1}$	$1.5x10^{-3}$	$1.5x10^{-2}$	$2.6x10^{-4}$	$5.3x10^{-3}$	$5.5x10^{-1}$
Nickel	$4.8x10^{-3}$	$4.1x10^{-3}$	$4.2x10^{-3}$	$7.6x10^{-4}$	$3.0x10^{-4}$	$3.0x10^{-3}$	$3.5x10^{-4}$	$1.2x10^{-2}$	$3.0x10^{-2}$
Selenium	$1.1x10^{-3}$	$9.4x10^{-6}$	$5.3x10^{-6}$	$1.8x10^{-3}$	$2.4x10^{-3}$	$2.4x10^{-2}$	$1.7x10^{-4}$	$8.0x10^{-1}$	$8.3x10^{-1}$

Note: COPC - Chemicals of Potential Concern; HQ - Hazard Quotient

Table 6.12.2-2: Summary of Risks in Humans – Carcinogenic

Metal COPC	ILCR								Total ILCR
	Soil			Surface Water	Plant	Berries	Wild Game	Fish	
	Ingestion	Dermal	Inhalation	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	
Arsenic	$1.0x10^{-5}$	$2.8x10^{-6}$	$1.0x10^{-7}$	$1.7x10^{-5}$	$2.5x10^{-7}$	$3.9x10^{-6}$	$1.0x10^{-6}$	$9.6x10^{-5}$	$1.3x10^{-4}$

Note: COPC - Chemicals of Potential Concern; ILCR - Incremental Lifetime Cancer Risk

6.12.2.4 Cultural Ecological or Community Knowledge

6.12.2.4.1 Nisga'a Nation

The Nisga'a Nation people have been inhabiting and using the area in and around the Nass River for thousands of years. The lives of the Nisga'a Nation people are tied closely to the land and resources in the Nass Valley and beyond. The Nisga'a Nation people fish, trap, and hunt a wide variety of marine and terrestrial species, and use a variety of aquatic and terrestrial plants, including berries. Salmon and oolichan are central to Nisga'a history, economy, and way of life. Resource use (e.g., fishing, wildlife, and plant harvesting and forestry) is still important in the Nisga'a way of life and economy.

The Nisga'a Final Agreement (NFA) (BC Ministry of Aboriginal Relations and Reconciliation (BC MARR) 2000) also defines Nisga'a Nation rights, title, and jurisdiction related to a range of health matters, including health services, fee simple land, and tenures proximate to the proposed Project site, water entitlements, wildlife and birds, fish and aquatics, and timber and non-timber forest products. The following list provides an overview of the rights and interests related to the proposed Project setting as defined by the NFA and transportation route:

- Within 5 km of the proposed Project the Nisga'a Nation has fee-simple title to Gits'oohl, and rights to a commercial recreation tenure (until 2027);
- The Nisga'a Nation have rights to use 10% of the volume in Kwinatahl River (approximately 2.5 km southeast of the Kitsault Project) for domestic, commercial, and industrial purposes;
- The Nisga'a Nation have rights to harvest wildlife in the Nass Wildlife Area (NWA), in particular allocations for grizzly bears, moose, and goats;
- The Nisga'a Nation have trapping rights to four traplines within the Kitsault area (none overlap directly with the proposed Project);
- The Nisga'a Nation have the right to harvest migratory birds in the Nass Area; and
- The Nisga'a Nation have the right to harvest salmon, steelhead, aquatic plants, oolichan, and intertidal bivalves within in the Nass Area. Sockeye and pink salmon represent the highest harvest among Nisga'a Nation citizens.

6.12.2.4.2 Aboriginal Groups

There are five Aboriginal groups that may be potentially affected by the Kitsault mine site and transportation route; however, only the Metlakatla First Nation's asserted territory overlaps with the mine site. The remaining Aboriginal groups' traditional territories overlap with the Kitsault transportation route (including Highway (Hwy) 37, Hwy 113, and / or Nass Forest Service Road (FSR). To date, Metlakatla First Nation has not raised any concerns regarding environmental health related to humans in proximity of the mine site, and desk-based research has not provided any information on this matter. Future consultation may provide additional information and understanding related to the Metlakatla First Nations and their potential interest in the proposed Project.

6.12.2.5 Past, Present, or Future Projects / Activities That May Interact With VC #1

The current assessment evaluates future potential risks to human health associated with the proposed Project, relative to baseline conditions that, by definition, would include any past or present projects in the vicinity. The following will be considered for the assessment;

- **Historical land use,** including previous mining and exploration activities and construction of the Kitsault Townsite, which is located 5 km from the proposed Project;
- **Current land use,** including nearby transportation and access roads, ongoing mining exploration, trapping and guide outfitting, marine boat traffic, and recreational fishing; and
- **Future land use,** including Northwest Transmission Line (NTL) Project

6.12.2.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to environmental health since they could adversely affect the long-term human health. Emphasis is placed on identifying metals as the COPCs, since metals usually pose the most potential for chronic health risks at mines. Mining projects often have high metals concentrations and volumes in mining wastes and dust generated from mining activities. High metal concentrations often persist in the environment. The environmental health component provides information, including chemical analyses and modelling results, and data through exposure modelling calculations to assess effects on human health.

6.12.2.6.1 Identification and Analysis of Potential Project Effects

Rather than evaluate the entire spectrum of metals that may be found at the proposed Project, a screening exercise was completed to identify the actual COPCs. If the 95^{th} percentile concentration of a metal was less than its respective screening criterion, then the metal was excluded as a COPC. Risk-based guidelines are purposely set by regulatory agencies to be conservative, so that they can be applied to screening procedures and provide confidence that if the guidelines are not exceeded, there will be no unacceptable risks to human receptors, regardless of the exposure scenario.

If the 95^{th} percentile of the baseline concentration of a metal is greater than its respective screening criterion, then the metal was selected as a COPC. The conservative approach taken to establish each screening guideline is such that an exceedance does not necessarily mean there is an unacceptable risk; rather, an exceedance simply serves to identify the chemical as being of potential concern so that the risks can be quantitatively assessed using site-specific exposure assumptions.

In total, 17 metals were identified as being associated with the proposed Project and therefore subjected to the above-described screening procedure. Five metals were retained as COPCs by the screening procedure for further assessment. The results of the COPC screening procedure are summarised in Table 6.12.2-3. A summary of all available soil and surface water data is provided in Appendix 1 of the Environmental Health Baseline Report (Appendix 6.12-A).

It is important to note that each of the COPCs retained in the risk assessment are naturally occurring elements. Human activities only serve to redistribute these naturally present metals, some of which have naturally high baseline concentrations.

Table 6.12.2-3: Screening of Chemicals of Potential Concern in Soil and Surface Water

Metal COPC	Soil Milligrams per Kilogram (mg/kg)			Surface Water Milligrams per Litre (mg/L)			
	95th Percentile of Soil Concentrations (a)	Screening Guideline		95th Percentile of Surface Water Concentrations (d)	Screening Guideline		
		CCME (b)	Government of BC (c)		Health Canada (e)	Government of BC (f)	Adjusted US EPA (PRGs) (g)
Antimony	5.0	20	20	0.0039	0.006	0.006	0.03
Arsenic	29.01	12	n/a	0.004	0.01	0.01	0.009
Barium	175.5	500	n/a	0.058	1	1	0.52
Beryllium	0.84	4	4	0.0003	n/a	n/a	0.015
Cadmium	0.97	10	n/a	0.0028	0.005	0.005	0.0036
Chromium	97.0	64	n/a	0.0011	0.05	0.05	0.022
Cobalt	26.2	50	50	0.00045	n/a	n/a	0.15
Copper	49.2	63	n/a	0.01	1	1	0.3
Lead	48.0	140	n/a	0.0032	0.01	0.01	NA
Mercury	0.25	6.6	n/a	0.00095	0.001	0.001	0.0022
Molybdenum	94.9	10	10	0.65	n/a	0.25	0.036
Nickel	99.4	50	100	0.0078	n/a	n/a	0.015
Selenium	1.4	1	3	0.0035	0.01	0.01	0.036
Silver	7.2	20	20	0.00005	n/a	n/a	0.036
Thallium	0.5	1	n/a	0.00015	n/a	n/a	0.00048

Metal COPC	Soil Milligrams per Kilogram (mg/kg)			Surface Water Milligrams per Litre (mg/L)			
	95th Percentile of Soil Concentrations (a)	Screening Guideline		95th Percentile of Surface Water Concentrations (d)	Screening Guideline		
		CCME (b)	Government of BC (c)		Health Canada (e)	Government of BC (f)	Adjusted US EPA (PRGs) (g)
Vanadium	98.1	130	200	0.0023	n/a	n/a	0.0072
Zinc	163.5	200	n/a	0.027	5	5	2.2

Note: BC - British Columbia; CCME - Canadian Council of Ministers of the Environment; COPC - Chemical of Potential Concern; HC - Health Canada; mg/kg - milligrams per kilogram; mg/L - milligrams per litre; PRG - Preliminary Remediation Goal; US EPA - United States Environmental Protection Agency. 1 - the background concentration these elements exceed the CCME and BC guidelines; (a) 95th percentile of soil concentrations. Concentrations provided by Rescan and AMEC Soil Quality Group. (b) Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guideline for the protection of human health" (CCME 2007). Value represents guideline protective of residential / parkland uses. (c) BC *Environmental Management Act*, *Contaminated Sites Regulation*, Schedule 4 Numeric Soil Standards. (d) 95th percentile of water concentrations at end of pipe discharge during construction and operations phases. Concentrations provided AMEC Water / Sediment Quality Group. Conservative concentrations at end-of-pipe discharge to Patsy Creek were used. (e) Health Canada drinking water quality guidelines (Health Canada 2008). (f) BC Water Quality Guideline (maximum) for Drinking Water for the Protection of Human Health (Government of BC 2011). (g) EPA Region IX Preliminary Remediation Goals (PRGs) for tap water (US EPA 2011) were adjusted according to CCME when using guidelines from other jurisdictions. Highlighted cell indicates metal is a COPC in specified medium. Metal was selected as a COPC in soil if the 95th percentile of the concentration exceeded screening guideline for soil, and in water if the 95th percentile of the concentration of end-of-pipe discharge exceeded screening guidelines for water

Screening for Soil

Analytical chemistry data for soil were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- BC *Contaminated Sites Regulations (*BC *CSR*) (Government of BC 2011) of the BC *Environmental Management Act (*BC *EMA*) (Government of BC 2003), Schedule 4 Generic Numerical Soil Standards, for park and residential use; and
- Canadian Environmental Quality Guidelines: “Canadian Soil Quality Guidelines (SQG) for the Protection of Environmental and Human Health” (CCME 2011), assuming a residential/parkland land use.

Screening for Surface Water

The reported concentration data for surface water were assessed and evaluated for the purposes of identifying COPCs using:

- BC “Water Quality Guidelines” (Government of BC 2011); and
- “Guidelines for Drinking Water Quality” (HC 2011).

In the absence of applicable Canadian guidelines, the screening for the COPCs used:

- The United States Environmental Protection Agency (US EPA) “Region IX PRGs” for tap water guidelines (US EPA 2011).

Summary of Screening for COPCs

Based on the screening conducted, the following chemicals have exceeded CCME, HC, and BC MOE guidelines and have been carried forward in the HHRA model for the effects assessment as COPCs in soil:

- Arsenic;
- Chromium;
- Molybdenum;
- Nickel; and
- Selenium.

Based on the screening conducted, it was found that molybdenum exceeded CCME, BC MOE, and US EPA guidelines and has been carried forward in the HHRA model for the effects assessment as COPCs in surface water:

Exposure Point Concentrations

Exposure Point Concentrations (EPCs) are chemical concentrations in soil surface water and foods to which receptors are assumed to be exposed. For the purpose of the HHRA, EPCs in soil, surface water, and country foods are assumed to be equivalent to the 95th

percentile concentration detected within the vicinity of the Project. A summary of soil, , and country foods data for the HHRA model can be found in Appendix 1 of the Environmental Health Baseline Report (Appendix 6.12-A).

Estimation of Potential Exposure via Incidental Ingestion and Dermal Contact with Soil

Similar to the baseline assessment, the exposures due to dermal contact are evaluated using oral exposures. For the incidental soil ingestion pathway, the degree of exposure depends on the amount of soil ingested on a daily basis, and the number of days per year that exposures are modelled to occur (i.e., the frequency and duration of exposure). The general equation used to calculate the dose due to soil ingestion and dermal contact is the same as the equation used in the baseline assessment described in the Environmental Health Baseline Report (Appendix 6.12-A).

Toxicity Assessment

The toxicity assessment includes:

- Hazard identification, which describes the potential adverse effects associated with a chemical and whether they are likely to occur in humans; and
- Dose-response evaluation, which quantifies the relationship between chemical dose and the incidence of adverse health effects in the exposed populations.

Exposure limits are usually developed by regulatory agencies (i.e., HC, US EPA), based on a technical review of all of the available scientific information, and application of professional judgment. These limits consider the most sensitive toxicological endpoints in individuals and include an adjustment of uncertainty factors. In general, such exposure limits are developed to protect the most sensitive individuals in a population, including sensitive life stages (e.g., pregnant women, the elderly) and individuals with compromised health (e.g., asthmatics). Typically, exposures below these exposure limits would not be associated with adverse health effects and thus would not represent a concern. As exposures increase to levels above prescribed exposure limits, the probability of increased health risk increases.

Carcinogens

Compounds with known or potential carcinogenic effects do not have a dose below which no adverse effect occurs. For carcinogens, the exposure limit is called a slope factor, which is an upper-bound estimate of the probability of a carcinogenic response per unit intake of a constituent over a lifetime. According to the US EPA (2011), either central or upper-bound estimates may be appropriate for evaluation of the carcinogenic risk or the selection of the estimate to be used is dependent on the type of assessment that may be required. Central estimates are applicable for characterising a typical individual's risk, while upper-bound estimates conservatively exaggerate the risk to ensure that the risk is not underestimated if the underlying model is correct. Central estimates are useful for assessing aggregate risk across a population and for comparing or ranking environmental hazards. Upper-bound estimates provide information about the precision of the comparison or ranking. Arsenic is the only carcinogenic metal of all the proposed Project's COPCs. The remaining metals are classified as non-carcinogens. Cancer Slope Factors (CSF) from HC (2007b) US EPA (2011), Texas Commission of Environmental Quality (TCEQ) (2011), and California EPA (CalEPA) (2011) are used in the current effects assessment. The Toxicological Reference Values (TRVs) utilised in this risk assessment for arsenic are summarised in Table 6.12.2-4.

Table 6.12.2-4: Toxicological Reference Values

Metal COPC	Oral TRV (mg/kg/d)	Dermal TRV (mg/kg/d)	Chronic Inhalation TRV (mg/m^3)	Inhalation TRV (mg/kg/d)	CSF		
					Oral	Dermal	Inhalation
					(1/mg/kg/d)		($1/mg/m^3$)
Arsenic	0.0003(a)	0.0003 (d)	0.000015 (f)	0.95 (e)	1.8 (a)	1.8 (d)	28 (a)
Chromium	0.001 (a)	0.001 (d)	0.0001 (b)	0.000056 (e)	n/a	n/a	n/a
Molybdenum	0.023 (a)	0.023 (d)	0.005 (c)	0.0028 (e)	n/a	n/a	n/a
Nickel	0.02 (b)	0.02 (d)	0.000018 (a)	0.00001 (e)	n/a	n/a	n/a
Selenium	0.0062 (a)	0.0062 (d)	0.0002 (c)	0.00011 (e)	n/a	n/a	n/a

Note: COPC - Chemical of Potential Concern; CSF - Cancer Slope Factor; mg/kg/d - milligrams per kilograms per day; mg/m3 - milligrams per cubic metre; n/a - not applicable; TRV - Toxicological Reference Value

Source: (a) HC (2007a; (b) US EPA (2011) – IRIS; (c) TCEQ 2011; (d) Extrapolation from oral TRV; (e) Extrapolation from inhalation TRV; (f) CalEPA 2011.

Non-Carcinogens

Compounds with known or potential non-carcinogenic effects are assumed to have a dose below which no adverse effect occurs, or conversely, above which an effect may (but not always) be seen. This toxicological reference value or dose is called the threshold dose. In laboratory experiments, this dose is known as the No Observable Adverse Effect Level (NOAEL), and is the lowest dose at which an adverse effect is seen. HC has used these types of values to derive the TRV for chronic exposures to compounds with potential non-carcinogenic effects. The TRV provides reasonable certainty that if the specified exposure dose is below the threshold, then no non-carcinogenic health effects are expected to occur even if daily exposure were to occur for a lifetime. The TRVs for non-carcinogens utilised in this risk assessment are summarised in Table 6.12.2-5. For compounds where TRVs were not available from HC, TRVs from a number of different jurisdictions including TCEQ (2011), CalEPA, (2011), and the US EPA (2011) were used.

It should be noted that the metals may exhibit different toxicological mechanisms of action depending on the route of exposure (i.e., ingestion, dermal, inhalation, dermal). Different TRVs are often provided for oral and inhalation exposure routes, depending on whether toxicity studies have been conducted and assessed for that route. In general, very few studies are available for dermal TRVs. The oral TRV value was adopted for all compounds that did not have a published dermal TRV.

Relative Absorption Factor

To estimate the potential risk to human health that may be posed by the presence of a COPC in various environmental media (such as soil, sediment, water, or air), it is first necessary to estimate the human exposure dose of each COPC. The exposure dose is similar to the administered dose or applied dose of a laboratory experiment. The exposure dose is then combined with an estimate of the toxicity of the compound to produce an estimate of risk posed to human health.

Relative Absorption Factor (RAF) is a correction factor used to adjust the human potential dose so that it is expressed in the same terms as the doses used to generate the dose-response curve in the dose-response study. The RAF is the ratio between the estimated human absorption factor for the specific medium and route of exposure, and the known or estimated absorption factor for the laboratory study from which the dose-response value was derived.

$$RAF = \frac{\text{(fraction absorbed in humans for the environmental exposure)}}{\text{(fraction absorbed in the dose-response study)}}$$

The use of an RAF allows the risk assessor to make appropriate adjustments if the efficiency of absorption between environmental exposure and experimental exposure is known or expected to differ because of physiological effects and / or matrix or vehicle effects. Relative absorption factors can be less than 1 or greater than 1, depending on the particular circumstances at hand. If it is thought that absorption from the site-specific exposure is the same as absorption in the laboratory study, then the RAF is 1.0.

A summary of RAFs used in the environmental health EA is provided in Table 6.12.2-5. It should be noted that dermal absorption values (RAFs) were obtained directly from HC (2007b), Risk Assessment Information System (RAIS) (2011), TCEQ (2011), and the CalEPA (2011).

Table 6.12.2-5: Summary of Relative Absorption Factors

Metal COPC	Oral Soil		Dermal Soil		Inhalation		Oral Surface Water	
	Cancer	Non-Cancer Chronic	Cancer	Non-Cancer Chronic	Cancer	Non-Cancer Chronic	Cancer	Non-Cancer Chronic
Arsenic	0.95 (e)	0.95 (e)	0.03 (a)	0.03 (a)	1 (d)	1 (d)	0.95 (e)	0.95 (e)
Chromium	n/a	0.013 (b)	n/a	0.1 (a)	n/a	1 (d)	n/a	0.013 (b)
Molybdenum	n/a	1 (e)	n/a	0.01 (a)	n/a	1 (d)	n/a	1 (e)
Nickel	n/a	0.2 (e)	n/a	0.2 (a)	n/a	1 (d)	n/a	0.2 (e)
Selenium	n/a	1 (e)	n/a	0.01 (a)	n/a	1 (d)	n/a	1 (e)

Note: COPC - Chemical of Potential Concern; n/a - not applicable

Source: (a) HC (2007b); (b) TCEQ (2011); (d) CalEPA (2011); (e) RAIS (2011)

Risk Characterisation

For the effects assessment of non-carcinogenic health effects, the calculated Chronic Daily Intake (CDI) is compared to the TRV. The detailed exposure and risk calculations are described in Appendix 2 of the Environmental Health Baseline Report (Appendix 6.12-A).

This comparison is accomplished by calculating a ratio, known as the Hazard Quotient (HQ). The HQ is calculated using the following formula:

$$HQ = \frac{Intake}{TDI}$$

where:	HQ =	Hazard quotient (no units)
	Intake =	Average daily or weekly exposure (milligrams per kilograms per day / milligrams per kilograms per week (mg/kg/d / mg/kg/w)
	TDI =	Tolerable daily or weekly intake (mg/kg/d-w)

HC and BC MOE accepts that when the HQ for a given COPC and pathway does not exceed 1, there are no unacceptable risks (HC 2007a).

For carcinogenic chemicals, the risk estimate (i.e., Incremental Lifetime Cancer Risk (ILCR)) was determined by the application of the following equation:

$$ILCR = Estimated \;\; Daily \;\; Intake \;\; x \; Toxico \log ical \;\; Reference \;\; Value$$

Based on HC (2007a), an ILCR greater than 10^{-5} (i.e., one-in-one hundred thousand) is considered to represent an unacceptable level of risk.

Quantitative Interpretation of Risk Hazard

Effects of the proposed Project generally have a low effect on human receptors. Risk modelling of the health effects of non-carcinogenic metals shows no risk from exposure to chromium, nickel, and selenium. Only exposure to arsenic and molybdenum exceeded the criteria with an estimate of risk of 1.8 and 1.07. It should be noted potential exposure scenarios were conservatively based on the assumption that a receptor would live in the LSA for 24 hours a day, 7 days a week, and 365 days a year for their exposure period (4.5 years for a toddler and entire life of 60 years for an adult). In the exposure scenarios, the receptor would be exposed to the 95th percentile of COPC concentrations in soil, water, fish and country foods every day. It was also under these conservative assumptions that the potential carcinogenic ILCR associated with baseline exposure of receptors identified for the proposed Project has been rated unacceptable for arsenic based on BC's target risk level of 10^{-5} (HC 2007) with a value of 3.5×10^{-4}. It was also concluded that the ILCR for all other carcinogens were below HC's target risk level of 10^{-5}.

A quantitative comparison of the estimated exposures and the selected exposure limits for the human receptor for soil, surface water, plants and berries, wild game, and fish are provided in Tables 6.12.2-6 and 6.12.2-7. The detailed exposure, and risk calculations for each receptor and environmental media are described in Appendix 2 of the Environmental Health Baseline Report (Appendix 6.12-A).

Table 6.12.2-6: Summary of Risks in Humans – Non-Carcinogenic

Metal COPC	HQ								Total HQ
	Soil			Surface Water	Plant	Berries	Wild Game	Fish	
	Ingestion	Dermal	Inhalation	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	
Arsenic	$4.4x10^{-1}$	$1.2\ x10^{-2}$	$1.5x10^{-3}$	$4.6x10^{-1}$	$8.8x10^{-4}$	$8.8x10^{-3}$	$3.5x10^{-3}$	$8.5x10^{-1}$	1.8
Chromium	$6.1x10^{-3}$	$4.0x10^{-2}$	$7.4x10^{-4}$	$1.2x10^{-4}$	$2.0x10^{-4}$	$2.0x10^{-3}$	$3.8x10^{-4}$	$2.5x10^{-2}$	$8.4x10^{-2}$
Molybdenum	$2.0x10^{-2}$	$1.7x10^{-4}$	$1.4x10^{-5}$	1.0	$1.8x10^{-3}$	$1.5x10^{-2}$	$2.9x10^{-4}$	$7.2x10^{-3}$	1.07
Nickel	$4.8x10^{-3}$	$4.1x10^{-3}$	$4.2x10^{-3}$	$2.8x10^{-3}$	$5.2x10^{-4}$	$3.0x10^{-3}$	$3.8x10^{-4}$	$1.5x10^{-2}$	$3.5x10^{-2}$
Selenium	$1.1x10^{-3}$	$9.4x10^{-6}$	$5.3x10^{-6}$	$2.0x10^{-2}$	$2.4x10^{-3}$	$2.4x10^{-2}$	$1.7x10^{-4}$	$8.2x10^{-1}$	$8.7x10^{-1}$

Note: COPC - Chemical of Potential Concern; HQ - Hazard Quotient

Table 6.12.2-7: Summary of Risks in Humans – Carcinogenic

Metal COPC	ILCR								Total ILCR
	Soil			Surface Water	Plant	Berries	Wild Game	Fish	
	Ingestion	Dermal	Inhalation	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	
Arsenic	$1.0x10^{-5}$	$2.8x10^{-6}$	$1.0x10^{-7}$	$1.4x10^{-4}$	$2.5x10^{-7}$	$3.9x10^{-6}$	$1.0x10^{-6}$	$1.9x10^{-4}$	$3.5x10^{-4}$

Note: COPC - Chemical of Potential Concern; ILCR - Incremental Lifetime Cancer Risk

6.12.2.7 Limitations

Assessing health risks from environmental chemicals is always associated with uncertainty. Where there is uncertainty, conservative assumptions have been used to ensure that risks have not been underestimated (and in fact have almost certainly been overestimated). In the exposure assessment, uncertainty relates to the assumptions regarding the presence of VCs. Conservative assumptions were made to ensure that any ecological receptors that may be present in the vicinity of the proposed Project site are provided with sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from published literature studies rather than directly measuring toxicity at the site, which is why there is some uncertainty associated with toxicity reference values. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs). This is because most reference values are based on the most sensitive species tested or based on a similar low effect level (e.g., 10th or 25th percentile of species sensitivity distribution). Further, toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e. the use of soluble metal salts).

Data availability was limited for this assessment. Air dispersion modelling for COPCs concentrations for baseline and proposed Project effects have not been completed for the ERA (Appendix 6.12-A and 6.12.2 of the effects assessment). Long-term ambient monitoring at near-by sites has not been implemented because of lack of anthropogenic activities, the proposed Project's remote location and difficult access, and likely ultra-low concentrations of CACs which would be below the detection limit of a typical portable monitoring station. Developing background concentration by mean of air dispersion modelling is also not feasible for the proposed Project because of a lack of specific emission sources. Baseline data for most exposure media pathways (i.e., soil, vegetation, berries) have been used because proposed Project effects data were unavailable for the ERA. Proposed Project effects data were used when available (i.e., surface water data).

For risk characterisation, the Exposure Ratios (ERs) generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring or will occur. There is greater inherent uncertainty associated with results of screening-level assessments than higher-tier assessments, because preliminary results are based on modelled or estimated concentrations and TRVs derived from literature studies, rather than direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure were made and no toxicity studies were performed.

6.12.2.8 Conclusion

Risk modeling of the health effects of non-carcinogenic metals using established formulas to determine PQRA shows no risk to humans from exposure to chromium, nickel, and selenium. Only exposure to arsenic and molybdenum exceeded the criteria, with estimates of risk of 1.8 and 1.1. It should be noted potential exposure scenarios were conservatively based on the assumption that a receptor would live in the LSA for 24 hours a day, 7 days a week, and 365 days a year for their exposure period (4.5 years for a toddler and a life span of 60 years for an adult In the exposure scenarios, the receptor would be exposed to the 95th percentile of COPC concentrations in soil, water, fish and country foods every day. It was under these conservative assumptions that the potential carcinogenic ILCR associated with baseline exposure of receptors identified for the proposed Project has been rated unacceptable for arsenic based on BC's target risk level of 10^{-5} (HC 2007) with a value of 3.5×10^{-4}. It was also concluded that the ILCR for all other carcinogens were below HC's target risk level of 10^{-5}.

Due to the conservative nature of the assumptions, it has been determined that negative effects are unlikely to occur (10.2.2.8.5 and 10.2.2.9), and mitigation measures that are additional to those outlined in other sections of the Application are not anticipated to be required.

6.12.3 VC #2: Mammals

6.12.3.1 Introduction

Mammals, including large and small carnivorous / omnivorous, herbivore ungulates, and small herbivorous furbearing mammals, have been selected as VCs to address concerns that their health could be adversely affected by chemicals introduced or mobilised in the environment as a result of the proposed Project.

Grizzly Bear

The grizzly bear (*Ursus arctos*) is the largest carnivore in BC, with males weighing up to 325 kilograms (kg) and females about 175 kg (Hatler et al. 2003). Grizzly bears are potentially exposed to COPCs via ingestion of soil, plant tissue and berries, small mammals, large mammals, fish, and surface water located in the vicinity of the proposed Project. For grizzly bears, an Average Daily Dose (ADD) (in units of mg/kg/d) is calculated by summing the uptake via ingestion of soil, plant tissue and berries, small and large mammals, fish, and surface water pathways. Estimated doses of COPCs in the grizzly bear were calculated using standard exposure equations, incorporating uptake from ingestion of soil and food (Sample and Suter 1994). Examples of the calculations for grizzly bears are provided in the baseline report (Appendix 6.12-A).

Seasonal availability and distribution of food is an important determinant of the grizzly bear's home range size. Grizzly bears are omnivorous and opportunistic in their feeding habits. Although diets vary among individual populations, vegetation and plants constitute approximately 91 percent (%) of diets of grizzly bears in BC (Hobson et al. 2000). The high percentage of vegetation in their diet also points to the importance of the ungulates in their early spring and late fall diets (McLellan and Hovey 1995).

Due to a large home range and a diverse concentration of suitable food resources, it is difficult to identify a definitive breakdown of a grizzly bear's diet in the vicinity of the proposed Project. Therefore, for the purposes of this ERA, it is assumed that a 250 kg (i.e., average-sized adult male / female) grizzly bear consumes 91% of its diet as vegetation and the remaining 9% of its diet as meat sources (i.e., small and large mammals and fish). The total ingestion rates of 6.4 kilograms per day (kg/d) of food and 14.2 litres per day (L/d) of water for the grizzly bear is estimated using body-weight scaling equations recommended by US EPA (1993). The ingestion rate of soil for the grizzly bear is estimated at a conservative 3% of total food intake (US EPA 1993). Table 6.12.3-1 lists the exposure parameters for the grizzly bear receptor.

Table 6.12.3-1: Exposure Parameters for Mammals in the Vicinity of the Proposed Project for All Project Phases

Mammal Receptor	Body Weight (kg)	Total Food Intake (kg/d)	Ingestion Rate (kg/day)								
			Soil (kg/d) (c)	Surface Water (L/d)	Plant Tissue (kg/d) (e)	Berries (kg/d) (e)	Soil Invertebrates (e)	Meat from Small Mammals (e)	Meat from Large Mammals (e)	Meat from Birds (e)	Meat from Fish (e)
Grizzly Bear	250	6.4 (a)	0.3	14.2 (d)	2.92	2.92	n/a	0.257	0.257	n/a	0.064
Moose	475	10.9 (a)	0.327	25.4 (d)	10.9	n/a	n/a	n/a	n/a	n/a	n/a
American Marten	1	0.069(b)	0.0024	0.099 (b)	0.0024	0.0024	0.029	0.031	n/a	0.0028	0.0014
Snowshoe Hare	1.23	0.081(a)	0.071	0.013 (b)	0.081	n/a	n/a	n/a	n/a	n/a	n/a

Note: kg - kilogram; kg/d - kilograms per day; L/d - litres per day; n/a - not applicable (a) Estimated using allometric equation for total food intake for mammals (total food intake kg = 0.0687 x body weight$^{0.822}$), US EPA (1993). (b) Based on Sample et al. 1996. Reference values for mammalian species. (c) Conservatively estimated at 3% of total dietary intake for grizzly bear and black-tailed deer (US EPA 1993). (d) Estimated using allometric equation for total water intake for mammals (total water intake L = 0.099 x body weight0.90), US EPA (1993). (e) Based on estimated percentage of total food in the diet

American Marten

American martens are opportunistic when it comes to its food habits (Chapman and Feldhamer 1982). Adult males weigh 1 kg while females are considerably smaller, with adults averaging about 650 to 700 grams (g) (Hatler et al. 2003). Small mammals, birds, fish, insects, and berries comprise the main diet of martens. These furbearers are potentially exposed to COPCs via ingestion of soil, berries, invertebrates, birds, fish, small mammals, and surface water located in the vicinity of the proposed Project. For martens, an ADD (in units of mg/kg/d) was calculated by summing the uptake via ingestion of soil, berries, soil invertebrates, birds, fish, small mammals, and surface water pathways. Examples of the calculations for small furbearing carnivores are provided in the baseline report (Appendix 6.12-A).

A number of factors, including location, habitat selection, and the availability of food influence the marten's diet. Food preferences can be linked to seasonal variability. Newby (1951) found that 45% of the food items in marten scat were mammals, 43% were invertebrates, 7% were plant remains, and 4% were birds. For the purposes of this ERA, it is assumed that a 1 kg (average weight of adult male) marten consumes 45% of its diet as mammals, 43% of its diet as invertebrates, 7% as plants and berries, 4% as birds and 1% as other (i.e., fish). The total ingestion rate of 0.069 kg/d food for the marten was estimated using body-weight scaling equations recommended by US EPA (1993). The total ingestion rate of 0.099 L/d of water for the marten was provided by Sample et al. (1996) and was used in the assessment. The ingestion rate of soil for the marten was estimated at a conservative 3% of total food intake (US EPA 1993). Table 6.12.3-1 lists the exposure parameters for the American marten receptor.

Moose

Moose are the largest members of the deer family, and are potentially exposed to COPCs via ingestion of soil, plant tissue, and surface water located in the vicinity of the proposed Project. For moose, an ADD (in units of mg/kg/d) was calculated by summing the uptake via ingestion of soil, plant tissue, and surface water pathways. Examples of the calculations for large ungulates are provided in the baseline report (Appendix 6.12-A).

Adult cows weigh on average 340 to 420 kg and adult bulls weigh 450 to 500 kg (Government of BC 2000). In BC, moose must eat up to 20 kg of food every day in the winter (Government of BC 2000). Moose feed on willows for winter food, cotton wood, paper birch, aspen, and other shrubs and herbs. For the purposes of this ERA, it was assumed that a 475 kg (average weight) moose consumes 100% of its diet as vegetation. The total ingestion rates of 10.9 kg/d for food and 25.4 L/d for water for the moose was estimated using body-weight scaling equations recommended by US EPA (1993). The ingestion rate of soil was estimated at a conservative 3% of total food intake (US EPA 1993). Table 6.12.3-1 lists the exposure parameters for the moose receptor.

Snowshoe Hare

Snowshoe hares are potentially exposed to COPCs via ingestion of soil, plant tissue, and surface water located in the vicinity of the proposed Project. For snowshoe hares, an ADD (in units of mg/kg/d) was calculated by summing the uptake via ingestion of soil, plant tissue, and surface water pathways. Examples of the calculations for hares are provided in the baseline report (Appendix 6.12-A).

Snowshoe hares eat a variety of plant materials. Their diet varies with the season. Green vegetation is consumed when available from spring to fall, and twigs, evergreen needles, and bark form the bulk of the snowshoe hare's winter diet. For the purposes of this ERA, it is assumed that a 1.23 kg (Sample et al. 1996) hare consumes 100% of its diet as vegetation. The total ingestion rate of 0.081 kg/d of food for the snowshoe hare was estimated using body-weight scaling equations recommended by US EPA (1993). The total ingestion rate of 0.013 L/d of water for the hare was provided by Sample et al. (1996) and was used in the assessment. The ingestion rate of soil was estimated at a conservative 3% of total food intake (US EPA 1993). Table 6.12.3-1 lists the exposure parameters for the snowshoe hare receptor.

6.12.3.1.1 Relevant Legislation and Legal Framework

The ERA has been completed according to accepted (ERA) methodologies and guidance published by BC MOE and associated guideline documents and referral agencies such as CCME (1996a, 1997) and US EPA (1998).

6.12.3.1.2 Spatial Boundaries

Spatial boundaries for the risk assessment correspond to the spatial boundaries of other environmental disciplines as necessary. The LSA and RSA are based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range and activities that would bring the receptor into contact with various environmental media. In any population of organisms, there was extensive variability among individuals for each of these parameters. For mammals, the LSA and RSA would be similar to that of the air quality study areas. The air quality discipline (Section 6.2) defines the LSA as 2 km wide surrounding the proposed Project footprint and the RSA as 2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).

6.12.3.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project, which are contingent on permitting, include four primary phases:

1. Construction Phase – estimated 25-month period. This includes:
    - Site clearing and preparation, earthworks such as excavating and site grading;

- Construction of mine site roads and power distribution lines on the site;
- Facilities, such as processing plant, Tailings Management Facility (TMF) starter embankment, reclaim pipe works;
- Camp complex; and
- May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).

2. Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years would be spent milling low-grade ore). This includes progressive reclamation.
3. Decommissioning and Closure Phase – estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase – estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse effects on local receiving waters. Stabilisation of the WRMF and TMF will also be considered in post-closure monitoring.

6.12.3.2 Information Sources and Methods

Environmental chemistry data have been obtained from other disciplines (i.e., water, air, soil, and vegetation) as necessary and compared to federal and provincial regulatory guidelines. Analytical chemistry data for soil and surface water have been assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2011), for residential / parkland land use;
- BC *CSR* of the BC *EMA*, Schedule 4 Generic Numerical Soil Standards, for park and residential use; and
- BC "Surface Water Quality Guidelines" (Government of BC 2011).

Ecological health risks were assessed by following Ecological Risk Assessment guidance materials recommended by the BC MOE (1998), CCME (1996a, 1997) and US EPA (1998).

In order to evaluate the overall exposure of ecological receptors to project-related emissions, mathematical models were used to predict changes in the COPC concentration in the different media from baseline conditions. The chemical composition of the surface waters in rivers and creeks forming the watershed in the vicinity of the proposed mine site can mainly be altered as a result of the surface run-off of chemicals from the site through drainage ditches or from the process-water outfall into any given water body. Chemicals in the surface water can be found in either the dissolved or suspended solid state.

Atmospheric depositions can also add to the increase in COPC concentration in water bodies but its overall contribution is much smaller than direct intake from discharge lines or site run-off.

The situation is different for soil and vegetation,. Atmospheric depositions (wet and dry) from project emissions are the only source of COPCs that can modify the soil chemical composition. Vegetation is affected by airborne emissions both through direct deposition and indirectly via uptake of deposited chemicals from the soil. For the Kitsault mine project, fugitive dust deposition modeling states that dust deposition along the haul road would be approximately 2.1 g/m^2/month five meters from the road, decreasing to 0.004 g/m^2/month within the LSA. These dust fall estimates are well below BC MOE objective of 8.7 g/m^2/month. Therefore, based on minimal atmospheric deposition, it is not expected that COPCs concentration in soil and vegetation surrounding the proposed mine site will be affected during the project phase.

6.12.3.3 Description of VC #2: Mammals

The Environmental Health Baseline Report (Appendix 6.12-A) summarises the baseline results of risks from the proposed Project to the health of mammals. Large and small carnivorous / omnivorous, herbivore ungulate, and small herbivorous furbearing mammals were assessed as a receptor in the baseline study. Risks to mammals were characterised by comparing the weight-normalised exposure estimates for each chemical to TRVs for each representative mammal.

Toxicological information for the COPCs with respect to the receptors of concern was not available. Therefore, surrogates species such as black-tailed deer (instead of moose) and mink (instead of American marten) were used in the baseline assessment because of the availability of the necessary toxicological information.

The baseline assessment was completed using site soils and water quality data to represent conditions prior to the proposed Project. The effects assessment presents the difference between the baseline assessment data and the effects assessment that used water quality data modelled for the construction, operation, and decommissioning phases of the proposed Project.

ERAs for all chemicals were below 1 for all the grizzly bear, black-tailed deer, and hare (Table 6.12.3-2); therefore, no adverse effects were predicted for the large carnivore / omnivore mammal, herbivore mammal, and small herbivore mammals. ERs for the mink exposed to molybdenum exceeded 1 while all other remaining COPCs were below 1 (see Table 6.12.3-2).

Table 6.12.3-2: Baseline Risk Estimates for Mammals

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Grizzly bear			
Arsenic	0.044	0.49	0.09
Cadmium	0.002	0.16	0.015
Chromium	0.17	0.67	0.25
Molybdenum	0.29	0.29	0.997
Nickel	0.23	8.2	0.03
Selenium	0.025	0.04	0.61
Black-tailed deer			
Arsenic	0.028	0.67	0.04
Cadmium	0.001	0.22	0.006
Chromium	0.10	0.92	0.11
Molybdenum	0.15	0.39	0.38
Nickel	0.145	11.22	0.013
Selenium	0.017	0.06	0.30
Mink			
Arsenic	0.014	1.85	0.073
Cadmium	0.011	0.59	0.18
Chromium	0.552	2.52	0.22
Molybdenum	11.4	1.08	10.5
Nickel	0.803	30.77	0.026
Selenium	0.081	0.15	0.53
Hare			
Arsenic	0.18	1.8	0.10
Cadmium	0.008	0.56	0.015
Chromium	0.70	2.4	0.29
Molybdenum	0.94	1.0	0.92
Nickel	1.06	29.2	0.036
Selenium	0.15	0.15	1.0

Note: COPC - Chemicals of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

6.12.3.4 Cultural Ecological or Community Knowledge

6.12.3.4.1 Nisga’a Nation

Nisga’a Nation citizens have the right to trap and hunt wildlife in the NWA, an area (16,101 km^2) surrounding Nisga’a Lands, in accordance with provincial and federal laws. This harvest is subject to measures that are necessary for conservation and legislation enacted for the purposes of public health or safety. It must be consistent with the communal nature of the Nisga'a Nation's domestic (i.e., food, social, and ceremonial purposes) harvest and Nisga'a traditional harvest seasons. Additionally, the harvest must not interfere with other authorised uses of Crown land.

The right to hunt is related to initially designated species, including grizzly bears, mountain goats, and moose. Nisga'a Nation citizens also have the right to trade or barter wildlife and wildlife with other Aboriginal groups and/or amongst themselves. The NFA defines the Nisga'a annual hunting allocation based on the annual allowable harvest of the designated species. The Nisga'a hunting right has the same priority as recreational and commercial harvesting interests. Table 6.12.3-3 summarises the allocation percentages of the allowable harvest per designated species.

Table 6.12.3-3: Nisga'a Wildlife Allocations of Designated Species

Designated Species	Total Allowable Harvest (TAH)	Nisga'a Wildlife Allocation
Moose	First 50 moose	80%
	Next 50 moose	32%
	Remaining	56%
	Maximum	170 moose
Mountain Goat	Any number	25% of TAH
Grizzly Bear	1-6 grizzly bears	40% of TAH
	7-8 grizzly bears	50% of TAH
	9-10 grizzly bears	40% of TAH
	10>	40% of 10 + 30% of remaining

Note: TAH - Total Allowable Harvest; % - percent

The NFA affords Nisga'a Nation citizens the rights to traplines that fall outside of Nisga'a Lands in accordance with provincial and federal laws. Four of the secondary traplines fall within the Kitsault land use study area, but none overlaps with mine infrastructure (listed in Schedule C of Chapter 9 in the NFA), including: TR614T 090, TR614T 092, TR614T 094, and TR614T 096.

6.12.3.4.2 Aboriginal Groups

Potentially affected Aboriginal groups, including Metlakatla First Nation, Kitsumkalum First Nation, Kitselas First Nation, Gitanyow Hereditary Chiefs, and Gitxsan Chiefs hunt and trap a wide range of wildlife within their respective asserted territories. The most commonly harvested species is moose, and the most commonly trapped furbearer is American Marten. Grizzly bear have cultural importance to Aboriginal groups in the area through the use of body parts for consumption and in ceremonial purposes. To date, Gitanyow Hereditary Chiefs have expressed concern about the potential effects of the proposed Project on the depressed moose population in the vicinity of the Cranberry River related to the mine-related traffic along the Kitsault transportation route. Aboriginal groups are concerned about wildlife mortality, and food safety and availability related to wildlife resources in the proximity of the mine site, and the Kitsault transportation route.

6.12.3.5 Past, Present, or Future Projects / Activities That May Interact With VC #2

The current assessment identifies future ecological health risks potentially associated with the proposed Project, relative to baseline conditions, which, by definition, would include any past or present projects in the vicinity. A review of the historical, current and potentially foreseeable future projects defined for the cumulative effects assessment was conducted and the following was considered to be representative for this assessment:

- **Historical land use,** including previous mining and exploration activities.

6.12.3.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to the environmental health since they could adversely affect the long-term health of mammals. Emphasis is placed on identifying metals as COPCs, since metals usually pose the most potential for adverse health risks at mines. Mining projects often have high metals concentrations and volumes in mining wastes and dust generated from mining activities, which often persist in the environment. The environmental health component provides information, including chemical analyses and modelling results, as well as data through exposure modelling calculations, to assess effects on the health of mammals.

6.12.3.6.1 Identification and Analysis of Potential Project Effects

Ecological COPCs were identified by screening the 95th percentile concentrations for soil and surface water against CCME guidelines (or other toxicity-based guidelines as appropriate) and local background concentrations. Baseline soil concentrations have been collected, and have been used as the basis for the PQRA and the assessment completed presented in this section. The baseline is representative of the existing brownfield conditions and have been considered representative of soil conditions and COPCs concentrations at the time of proposed Project closure. Proposed Project effects data for surface water for all Project phases were used for the assessment due to the availability of predictive modeling tools to assess the potential effects to surface water conditions. Chemicals were assessed in the ERA if the 95th percentile concentration exceeded the relevant guideline, or the detection limit exceeded the guideline. The results of the COPC screening are summarised in Table 6.12.3-3.

For the purpose of the ERA, the assessment findings were compared to the CCME (2011) “residential / parkland” as conditions at the site as a result of the proposed Project activities are anticipated: (1) to be dominated primarily of open reclaimed and re-contoured areas of shrubs and grasses, wooded areas and barren areas; and (2) to provide habitat for ecological receptors.

Table 6.12.3-4: Screening of Chemicals of Potential Concern in Soil and Surface Water for Ecological Receptors

Metal COPCs	Soil (mg/kg)			Surface Water (mg/L)	
	95th Percentile of Soil Concentrations (a)	Screening Guideline		95th Percentile of Surface Water Concentration (All Phases) (d)	Screening Guideline
		CCME (b)	Government of BC (c)		Government of BC, Protection of Wildlife
Antimony	5.0	20	20	0.02	n/a
Arsenic	29.0	12	n/a	0.013	0.025 (f)
Barium	175.5	500	n/a	0.056	n/a
Beryllium	0.84	4	4	0.0007	n/a
Cadmium	0.97	10	n/a	0.0029	0.08 (h)
Chromium	97	64	n/a	0.001	0.05 (h)
Cobalt	26.2	50	50	0.00034	1 (h)
Copper	49.2	63	n/a	0.012	0.3 (f)
Lead	48.0	140	n/a	0.011	0.1 (h)
Mercury	0.25	6.6	n/a	0.00019	0.003 (h)
Molybdenum	94.9	10	10	1.6	0.05 (e)
Nickel	99.4	50	100	0.02	1 (h)
Selenium	1.4	1	3	0.015	0.004 (e)
Silver	7.2	20	20	0.00006	n/a
Thallium	0.5	1	n/a	0.00011	n/a
Vanadium	98.1	130	200	0.003	0.1 (h)
Zinc	163.5	200	n/a	0.065	2 (g)

Note: BC - British Columbia; CCME - Canadian Council of Ministers of the Environment; COPC - Chemical of Potential Concern; mg/kg - milligrams per kilogram; n/a - not applicable (a) 95th percentile of baseline soil concentrations. Concentrations provided by Rescan and AMEC Soil Quality Group. (b) CCME Soil Quality Guideline for the Protection of Environmental Health (CCME 2011). Value represents guideline protective of residential / parkland uses. (c) *BC Environmental Management Act*, *Contaminated Sites Regulation*, Schedule 4 Numeric Soil Standards. (d) 95th percentile of project effects surface water concentrations (all project phases). Concentrations provided by AMEC Water / Sediment Quality Group. (e) BC Water Quality Guideline (30-day average) for the Protection of Wildlife (Government of BC 2011). (f) BC Water Quality Guideline (maximum) for the Protection of Wildlife (Government of BC 2011). (g) BC Water Quality Guideline (interim maximum) for the Protection of Wildlife (Government of BC 2011). (h) BC Water Quality Guideline (maximum) for the Protection of Livestock (surrogate for wildlife) (Government of BC 2011). Highlighted cell indicates metal is a COPC in specified medium for ecological risk assessment. Metal was selected as a COPC in soil if the 95th percentile of the baseline concentration exceeded screening guideline in soil; and in water if 95th percentile of the project effects (all phases) concentration exceeded screening guidelines in water

Screening for Soil

Analytical chemistry data for soil were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2011), for residential / parkland land use; and
- BC *CSR* of the BC *EMA*, Schedule 4 Generic Numerical Soil Standards, for park and residential land use.

In the absence of a CCME guideline for a specific chemical, concentrations were screened against the BC *CSR*, Schedule 4 Generic Numerical Standards, assuming a residential / parkland land use. These criteria were developed to protect both environmental and human health.

Screening for Surface Water

The reported concentration data for surface water were assessed and evaluated for the purposes of identifying COPCs using:

- BC "Surface Water Quality Guidelines" (Government of BC 2011).

Summary of Identified COPCs

Based on the screening conducted for soil concentrations (Table 6.12.3-3), the following compounds were identified COPCs in soil for mammals and were carried forward in the ERA for the proposed Project:

- Arsenic;
- Chromium;
- Molybdenum;
- Nickel; and
- Selenium.

The remaining COPCs found in soil were below their respective guidelines and were not carried forward in the assessment.

Based on the screening conducted for surface water concentrations (Table 6.12.3-2), molybdenum and selenium have been identified as COPCs in surface water for mammals and were carried forward in the ERA for the proposed Project.

The remaining COPCs found in surface water were below their respective guidelines for wildlife health and were not carried forward in the assessment.

Exposure Assessment

The exposure assessment includes an analysis of the pathways through which VCs may be exposed to COPCs and an estimate of the concentrations to which they may be exposed. For COPCs to have deleterious effects on ecological receptors, the COPC must have contact with the organism or receptor. The route by which this occurs is referred to as an exposure pathway and is dependent on the nature of the chemical and the nature of the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of COPCs must be present;
- Release and transport mechanisms and media must be available to move the COPC from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the COPC is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

Exposure assessment consists of several steps, including the identification of COPCs, description of the fate and transport of COPCs in the environment, an examination of potential exposure pathways, and estimation of exposure levels for each VC.

Pathway Analysis

Incidental Soil Ingestion

Wildlife can be exposed to contaminants in soil via several pathways, including ingestion and dermal contact. While both pathways can potentially result in uptake depending on the properties of the chemical, the dominant pathway for mammals is usually through ingestion. The presence of fur limits the amount of contact that chemicals have with skin; soil adhered to fur is ultimately ingested during grooming (Sample and Suter 1994).

Soil comprises a small fraction of the diet for many organisms. The actual quantity of soil ingested depends on the life history traits of each species. For example, burrowing mammals which are frequently in direct contact with soil, may ingest significantly more quantities of soil compared to non-burrowing mammals. Another major source of soil ingested by mammals is soil adhered to the surface and the gut of prey items. Quantities of soil ingested from these different sources are not typically distinguished in ERAs; rather, exposure is quantified through the estimation of the average overall soil consumption (as a fraction of diet) for each species.

Although the COPCs may be consumed by an organism, only a fraction is absorbed through the gut and is available to cause toxicity. This uptake depends on a number of site-specific and organism-specific factors, which complicates the ability to define actual exposures. Therefore, this risk assessment incorporates conservative assumptions which assume that the entire quantity of COPCs in the soil ingested by large and small mammals is bioavailable and can potentially result in adverse effects.

Ingestion of Food / Prey

In addition to the soil consumed through their prey, omnivorous wildlife such as the marten can also be exposed to COPCs in the soil via consumption of vegetation (e.g., leaves, berries) that have bioaccumulated COPCs from the soils. Plants growing in soils containing elevated concentrations of chemicals may accumulate and can potentially distribute those chemicals to portions of the plant consumed by herbivores and omnivores. Similarly, soil invertebrates in contact with contaminated soil can accumulate metals which can be assimilated by martens upon consumption of prey.

Exposure Estimates

Exposure estimates are provided for mammals with complete exposure pathways. The exposure estimates are presented as weight-normalised daily doses. An ADD (in units of mg/kg/d) is calculated by summing the exposure doses for each exposure pathway. Examples of the calculated ADD of COPCs for mammals are provided in the baseline report (Appendix 6.12-A). The 95th percentile concentrations in each environmental media have been used to determine the ADD for mammals (Table 6.12.3-5).

Table 6.12.3-5: Ecological Risk 95th Percentile Concentrations

Metal COPC	95th Percentile Surface Water Concentration (mg/L)	95th Percentile Soil Concentration (mg/kg)	95th Percentile Plant Tissue Concentration (mg/kg)	95th Percentile Berries Concentration (mg/kg)	95th Percentile Fish Concentration (mg/kg)	95th Percentile Sediment Concentration (mg/kg)
Arsenic	0.0129	29.0	0.025	0.025	0.13	340.3
Chromium	0.0015	97.0	0.50	0.50	0.45	88.7
Molybdenum	1.61	95.0	1.4	1.1	0.03	n/a
Nickel	0.028	99.5	1.7	1.0	0.26	n/a
Selenium	0.016	1.4	0.50	0.50	0.89	n/a

Note: COPC - Chemical of Potential Concern; mg/kg - milligrams per kilogram; mg/L - milligrams per litre; n/a - not applicable

Toxicity Assessment

The following describes the potential adverse effects on mammals associated with exposure to COPCs. For each mammal, TRVs were identified that represented concentrations of COPCs in the various environmental media that would not result in adverse health effects:

Arsenic

Toxicity due to inorganic exposures may result in dermal or neurological symptoms in mammals. Dermal effects may include hyperpigmentation or hyperkeratosis on the palms, soles, and torso. Peripheral neuropathy may appear with symmetrical paresthesia. Neurotoxicity begins with sensory changes, paresthesia, and muscle tenderness, followed by weakness, which progresses from proximal to distal muscle groups. Chronic hepatic and renal damage is common with jaundice due to liver injury.

An Ecological Soil Screening Level (Eco-SSL) for mammals has been calculated by the US EPA (2005). This was based on a comparison of the geometric mean of the (NOAEL) values for growth and reproduction from a number of studies with the LOAEL for reproduction, growth, or survival. The geometric mean of NOAEL values was 2.47 mg arsenic per kg/d. However, this value was higher than the lowest bounded LOAEL. Therefore, the TRV was established at 1.04 mg/kg/d, representing the highest NOAEL, which was still lower than the lowest LOAEL for reproduction, growth or survival.

The NOAELs (or LOAELs) based on reproduction, growth, or mortality endpoints in rats and mice were adjusted using standard allometric relationships (Sample et al. 1996). If a NOAEL is available for a mammalian test species ($NOAEL_t$), then the equivalent NOAEL for a mammalian wildlife species ($NOAEL_w$) can be calculated by using the adjustment factor to account for differences in body size (Sample et al. 1996):

$$NOAEL_w = NOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4}$$

where	$NOAEL_t$ =	the NOAEL reported in the study for the test species;
	BW_t =	body weight of the test species; and
	BW_w =	body weight of the mammals used in the assessment.

Body weights for test species were obtained from either Sample et al. (1996) or US EPA Eco-SSL (2005). Body weights of the mammals used in this assessment and the adjusted TRVs are presented in Table 6.12.3-6.

Table 6.12.3-6: Toxicological Reference Value Derivations for Mammals

Receptor	Test Species (a)	Test Species Body Weight (kg) (a)	Receptor Body Weight (kg)	TRV (mg/kg/d) (b)	Adjusted TRV (mg/kg/d) (c)
Arsenic					
Grizzly Bear	Dog	10	200	1.04	0.49
Moose	Dog	10	475	1.04	0.40
American Marten	Dog	10	1	1.04	1.85
Snowshoe Hare	Dog	10	1.23	1.04	1.76
Chromium					
Grizzly Bear	Rat	0.35	200	3.28	0.67
Moose	Rat	0.35	475	3.28	0.54
American Marten	Rat	0.35	1	3.28	2.52
Snowshoe Hare	Rat	0.35	1.23	3.28	2.40
Molybdenum					
Grizzly Bear	Mouse	0.03	200	2.6	0.29
Moose	Mouse	0.03	475	2.6	0.23
American Marten	Mouse	0.03	1	2.6	1.08
Snowshoe Hare	Mouse	0.03	1.23	2.6	1.0
Nickel					
Grizzly Bear	Rat	0.35	200	40	8.2
Moose	Rat	0.35	475	40	6.6
American Marten	Rat	0.35	1	40	30.8
Snowshoe Hare	Rat	0.35	1.23	40	29.2
Selenium					
Grizzly Bear	Rat	0.35	200	0.2	0.04
Moose	Rat	0.35	475	0.2	0.03
American Marten	Rat	0.35	1	0.2	0.15
Snowshoe Hare	Rat	0.35	1.23	0.2	0.15

Note: kg - kilogram; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value (a) Studies on test species and body weight provided by US EPA Eco-SSL (2005) and Sample et al. (1996). (b) Eco-SSL) for mammals calculated by the US EPA (2005) or a geometric mean of the NOAEL values for reproduction and growth calculated by (Sample et al. 1996). (c) NOAEL for a mammalian wildlife species ($NOAEL_w$) calculated by using the adjustment factor for differences in body size (Sample et al. 1996)

Chromium

Although chromium was identified as a COPC, it was also identified as an essential nutrient for animals (NRC 1997). Chromium (III) has been shown to have antioxidative properties *in vivo* and it is integral in activating enzymes and maintaining the stability of proteins and nucleic acids. Its primarily metabolic role is to potentiate the action of insulin through its presence in an organometallic molecule called the glucose tolerance factor. Ingestion of high amounts of chromium (VI), on the other hand, causes gastrointestinal effects in animals, including abdominal pain, vomiting, and hemorrhaging (Agency for Toxic Substance and Disease Registry (ATSDR) 1998).

A geometric mean of the NOAEL values for reproduction and growth was calculated (i.e., 3.28 mg chromium per kg BW/d) (Sample et al. 1996). This value was then adjusted by body weight scaling for each individual mammalian receptor (Table 6.12.3-6).

Molybdenum

Molybdenum, an essential nutrient for animals, is usually found in nature as molybdenite (MoS_2), and is a cofactor for several enzymes in animals. The toxic properties of molybdenum in mammals are governed by its interaction with copper and sulphur (Eisler 1989). Some of the effects of an overabundance of molybdenum in mammals include reduced growth, hair loss, dermatosis, anemia, and skeletal and joint deformities (Chappell et al. 1979).

A geometric mean of the LOAEL values for reproduction and growth was calculated i.e., 2.6 mg molybdenum/kg BW/day (Sample et al. 1996). This value was then adjusted by body weight scaling to derive a TRV for each individual mammalian receptor.

Body weights of the mammals used in this assessment and the adjusted TRVs are presented in Table 6.12.3-6.

Nickel

Nickel occurs naturally in the environment at low levels and is an essential element in some animal species. Effects of nickel toxicity in mammals include pulmonary fibrosis, renal edema, sperm abnormalities, and decreased sperm count (ATSDR 1997).

A geometric mean of the LOAEL values for reproduction and growth was calculated (i.e., 40 mg nickel/kg BW/day (Sample et al. 1996). This value was then adjusted by body weight scaling to derive a TRV for each individual mammalian receptor.

Body weights of the mammals used in this assessment and the adjusted TRVs are presented in Table 6.12.3-6.

Selenium

Selenium is an essential trace element in animals and has been shown to be a natural component in the enzyme glutathione peroxidase and other proteins. Selenium toxicity is most likely to occur in animals grazing on seleniferous forage, or as a result of including seleniferous grain in their diet. Acute effects in animals following the ingestion of plants containing high levels of selenium include abnormal posture and movement, watery diarrhea, labored respiration, abdominal pain, prostration, and death. Chronic effects in animals include alkali disease and blind staggers. In wildlife, elevated selenium concentrations in the diet are associated with adverse reproductive and developmental effects including reduced growth or survival of young (Ohlendorf 1989).

A geometric mean of the LOAEL values for reproduction and growth was calculated at 0.2 mg selenium/kg BW/day (Sample et al. 1996). This value was then adjusted by body weight scaling to derive a TRV for each individual mammalian receptor.

Body weights for test species were obtained from either Sample et al. (1996) or US EPA Eco-SSL (2005). Body weights of the mammals used in this assessment and the adjusted TRVs are presented in Table 6.12.3-6.

Risk Characterisation

Determining ERs involves a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure Ratio} = \frac{\text{Exposure Estimate}}{\text{TRV}}$$

ERs are interpreted as follows:

If the ER is less than 1, no unacceptable risks to mammals would be expected because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds 1, it may be inferred that adverse effects to individuals are possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV that was based on a 25% reduction in a growth-based endpoint (ER>1), it can be inferred that one possible outcome may be diminished growth of individuals in a population. This can potentially (but not necessarily) lead to a reduction in population abundance of that receptor. It is important to note that exceeding an ER of 1 does not necessarily mean that adverse effects will definitively occur; rather, it suggests that we have less confidence that adverse effects will not occur. It is also important to recognise that the magnitude of the ER is not directly associated with the magnitude of potential effects. That is, a large ER (>10) should not be interpreted as a 10-fold greater risk than an ER of 1.

For those COPCs with ERs greater than 1, potential risks at a population level cannot be ruled out and should be evaluated further. Evidence from sources other than chemical analysis may be employed, including evidence of toxicity at the proposed Project site, toxicity of media in laboratory exposures (i.e., bioassays), the absence of species formerly present or commonly found at similar sites, or diminished populations compared to a reference location.

Quantitative Interpretation of Risk Hazard

Risks to mammals exposed to COPCs in all potential pathways were characterised by comparing the weight-normalised exposure estimates for each COPC to TRVs for the grizzly bear, moose, American marten, and the snowshoe hare. Risk estimates for mammals are presented in Table 6.12.3.7.

Table 6.12.3-7: Risk Estimates for Mammals

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Grizzly bear			
Arsenic	0.024	0.47	0.05
Chromium	0.086	0.63	0.14
Molybdenum	0.36	0.27	1.3
Nickel	0.11	7.7	0.01
Selenium	0.014	0.04	0.37
Moose			
Arsenic	0.021	0.40	0.05
Chromium	0.078	0.54	0.15
Molybdenum	0.18	0.23	0.79
Nickel	0.11	6.6	0.017
Selenium	0.013	0.03	0.40
American Marten			
Arsenic	0.078	1.85	0.04
Chromium	0.41	2.52	0.16
Molybdenum	1.02	1.08	0.94
Nickel	0.64	30.77	0.021
Selenium	0.08	0.15	0.52
Snowshoe Hare			
Arsenic	0.06	1.76	0.04
Chromium	0.31	2.4	0.13
Molybdenum	0.48	1.03	0.47
Nickel	0.54	29.2	0.018
Selenium	0.12	0.15	0.79

Note: COPC - Chemicals of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

For some mammals, ERs for certain COPCs were higher in the effects assessment (Table 6.12.4-6) when compared to baseline conditions. The ERs for all COPCs were below 1 for the moose, American marten, and the snowshoe hare. The ER for molybdenum exceeded 1 only for the grizzly bear while the ERs for the remaining COPCs were below 1.

6.12.3.7 Limitations

Assessing health risks that could result from exposure to environmental COPCs is a process that is unavoidably associated with uncertainty. Consequently, as uncertainty was identified in the risk assessment process, conservative assumptions were made to ensure that risks were not underestimated (and in fact were over-estimated). In the exposure assessment, uncertainty relates to the assumptions regarding the presence of VCs. Additional species were added to this effects assessment, and conservative assumptions were made to ensure any ecological receptors that might be present in the vicinity of the proposed Project site will be provided sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, which is why there is some uncertainty associated with toxicity reference values. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs); this is because most reference values are based on the most sensitive species tested or a similar low effect level (e.g., 10^{th} or 25^{th} percentile of species sensitivity distribution). Further, toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e., the use of soluble metal salts).

COPCs emissions data were not available for this assessment. Emissions data can be an important component of a risk assessment as it can be a key pathway for the dispersion of COPCs. Air dispersion modeling for COPCs concentrations for baseline and proposed Project effects was not completed for the ERA (Appendix 6.12-A). Long-term ambient monitoring at near-by sites has not been implemented because of lack of anthropogenic activities, the remote location and its difficult access, and likely ultra-low concentrations of CACs which are anticipated to be below the detection limit of a typical portable monitoring station. Developing background concentration by means of air dispersion modelling is also not feasible for the proposed Project because of a lack of specific emission sources. Baseline data for most exposure media pathways (i.e., soil, vegetation, berries) were used because proposed Project effects data were unavailable for the ERA. Proposed Project effects data were used when available (i.e., surface water data).

For risk characterisation, the ERs generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring. There is greater inherent uncertainty associated with results of screening level assessments than higher-tier assessments, because results are primarily based on modelled or estimated concentrations and TRVs derived from literature studies, rather than on direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure were made and no toxicity studies were performed. In many cases, toxicity at a site is considerably diminished compared to effects predicted from laboratory studies for a variety of reasons. Higher-tier assessments (i.e., Preliminary Quantitative ERA) incorporate site-specific toxicity data in a lines-of-evidence approach, which can reduce the level of uncertainty during this phase of environmental assessment.

Risk estimates presented in the environmental assessment section of this Application differ from the baseline. For some mammals, ERs for certain COPCs were higher in the effects assessment (Table 6.12.3-6) when compared to baseline (Table 6.12.3-2) conditions and / or estimates. Available proposed Project effects data used in the ERA were limited to surface water only and may have contributed in the change in ERs from baseline assessment to the effects assessment. Different exposure pathways (i.e., ingestion of birds) and characteristics (i.e., bodyweight) have also been applied to the effects assessment, which may have resulted in ER changes.

6.12.3.8 Conclusion

Quantitative estimates of risk were calculated using a quotient approach in which exposure estimates based on 95^{th} percentile concentrations were compared to TRVs derived for each receptor / pathway. ERs greater than 1 were found for the grizzly bear which potentially could be exposed to molybdenum in soil, water, and vegetation, while ERs for all remaining COPCs for were below 1, as presented in Table 6.12.3-5.

6.12.4 VC #3: Birds

6.12.4.1 Introduction

Birds, including raptors, songbird, terrestrial birds, waterfowl, and shorebirds have been selected as VCs to address concerns that their health could be potentially adversely affected by COPCs introduced or mobilised into the environment as a result of the proposed Project.

Northern Goshawk

Raptors or birds of prey such as northern goshawk (*Accipiter gentilis*) were assessed as a receptor and were identified as a VC in the region. It is assumed that if risks were acceptable for a northern goshawk, then risks would be acceptable for all raptors. The northern goshawk is carnivorous, preying on a variety of small birds and mammals. The goshawk can weigh up to 1.4 kg (BC MOE 1998). Northern goshawks are potentially exposed to COPCs via ingestion of small mammals, other birds, and surface water located in the vicinity of the proposed Project. An ADD (in units of mg/kg/d) was calculated by summing the uptake via ingestion of small mammals, birds, and surface water pathways. Examples of the calculations for raptors are provided in the baseline report (Appendix 6.12-A).

For the purpose of this assessment, it is assumed that a 1.4-kg goshawk, which preys on small mammals and other birds, consumes 50% of its diet as small mammals and 50% of its diet as birds. The total ingestion rates of 0.073 kg/d of food and 0.074 L/d of water for the goshawk was estimated using BW scaling equations recommended by US EPA (1993). Table 6.12.4-1 lists the exposure parameters for the northern goshawk.

Table 6.12.4-1: Exposure Parameters for Birds in the Vicinity of the Proposed Project for All Project Phases

Mammal Receptor	Body Weight (kg)	Total Food Intake (kg/d)	Soil (kg/d) (b)	Ingestion Rate (kg/d)						
				Surface Water (L/d)	Plant Tissue (d)	Soil Invertebrates (d)	Meat from Small Mammals (d)	Meat from Birds (d)	Meat from Fish (d)	Aquatic Invertebrates (d)
Northern Goshawk	1.4	0.073 (a)	n/a	0.074 (c)	n/a	n/a	0.036	0.036	n/a	n/a
Olive-sided Flycatcher	0.037	0.0068 (a)	0.0002	0.0065 (c)	n/a	0.0068	n/a	n/a	n/a	n/a
Sooty Grouse	1.28	0.068 (a)	0.0021	0.070 (c)	0.068	n/a	n/a	n/a	n/a	n/a
Common Loon	4.0	0.14 (a)	n/a	0.15 (c)	n/a	n/a	n/a	n/a	0.14	n/a
Spotted Sandpiper	0.055	0.0088(a)	0.0008	0.0085 (c)	n/a	n/a	n/a	n/a	n/a	0.0085

Note: kg - kilogram; kg/d - kilograms per day; L/d - litres per day; n/a - not applicable (a) Estimated using allometric equation for total food intake for birds (total food intake kg = 0.00582 x body weight$^{0.651}$), US EPA (1993). (b) Conservatively estimated at 3% of total dietary intake (US EPA 1993). (c) Estimated using allometric equation for total water intake for birds (total water intake L = 0.059 x body weight$^{0.67}$), US EPA (1993). (d) Based on estimated percentage of total food in the diet.

Olive-Sided Flycatcher

Songbirds were assessed as a receptor and were identified as a VC. The olive-sided flycatcher (*Contopus cooperi*) is commonly found in the region and was therefore assessed as a representative species. It is assumed that if risks were acceptable for a typical flycatcher, then risks would be acceptable for all songbirds. Songbirds feed on a variety of invertebrates and can weigh up to 0.037 kg (Altman et al. 2000). Olive-sided flycatchers are potentially exposed to COPCs via ingestion of soil, soil invertebrates, and surface water in the vicinity of the proposed Project. An ADD (in units of mg/kg/d) was calculated by summing the uptake via ingestion of soil, soil invertebrates, and surface water pathways. Examples of the calculations for songbirds are provided in the baseline report (Appendix 6.12-A).

For the purposes of this risk assessment, it is assumed that a 0.037-kg olive-sided flycatcher consumes 100% of its diet as soil invertebrates. The total ingestion rates of 0.0068 kg/d of food and 0.0065 L/d of water for the flycatcher were estimated using body-weight scaling equations recommended by US EPA (1993). The ingestion rate of soil for songbirds was estimated at a conservative 3% of total food intake (US EPA 1993). Table 6.12.4-1 lists the exposure parameters for the olive-sided flycatcher.

Sooty Grouse

Terrestrial birds were assessed as a receptor and were identified as a VC. The sooty grouse (*Dendragapus fuliginosus*) is commonly found in the region and was assessed as a representative species. It is assumed that if risks were acceptable for a typical sooty grouse, then risks would be acceptable for all terrestrial birds. Grouse are forest-dwelling and their diet is dominated by plant material, which forms 100% of their diet. Sooty grouse can weigh 0.835 kg to 1.280 kg (Klinkenberg 2010), and may potentially be exposed to COPCs via ingestion of soil, vegetation, and surface water in the vicinity of the proposed Project. An ADD (in units of mg/kg/d) was calculated by summing the potential uptake via ingestion of soil, vegetation, and surface water pathways. Examples of the calculations are provided in the baseline report (Appendix 6.12-A).

For the purposes of this risk assessment, it is assumed that a 1.28-kg sooty grouse consumes 100% of its diet as vegetation. The total ingestion rates of 0.084 kg/d of food and 0.07 L/d of water for the sooty grouse were estimated using BW scaling equations recommended by US EPA (1993). The ingestion rate of soil for the grouse was estimated at a conservative 3% of total food intake (US EPA 1993). Table 6.12.4-1 lists the exposure parameters for the sooty grouse.

Common Loon

Waterfowl were assessed as a and have been identified as a VC. The common loon (*Gavia pacifica*) is identified in the region and was therefore assessed as a representative species. It is assumed that if risks were acceptable for a typical loon, then risks would be acceptable for all waterfowl. The predominant pathways by which waterfowl may be exposed to COPCs at the proposed Project include ingestion of food and water, since waterfowl feed on a variety of fish. Loons are heavy birds because of their solid bones; weight varies, ranging from 1.6 to 8 kg with an average of about 3 to 4 kg (McIntyre et al. 1997). An ADD (in units of mg/kg/d) was calculated by summing the uptake via ingestion of fish and surface water pathways. Examples of the calculations are provided in the baseline report (Appendix 6.12-A).

For the purposes of this risk assessment, it is assumed that a 4-g loon consumes 100% of its diet as fish (McIntyre 1988). The total Ingestion rates of 0.144 kg/d of food and 0.15 L/da of water for waterfowl were estimated using body-weight scaling equations recommended by US EPA (1993). Table 6.12.4-1 lists the exposure parameters for the common loon.

Spotted Sandpiper

Shorebirds were assessed as a receptor and have been identified as a VC. The spotted sandpiper (*Actitis macularius*) was identified in the region and was assessed as a representative species. It is assumed that if risks were acceptable for a typical spotted sandpiper, then risks would be acceptable for all shorebirds. Shorebirds feed on a variety of invertebrates (Klinkenberg 2010), and are potentially exposed to COPCs via intake of surface water and sediment during the ingestion of aquatic invertebrates. Shore birds can weigh 0.035 kg to 0.055 kg (Klinkenberg 2010). An ADD (in units of mg/kg/d) was calculated by summing the uptake via ingestion of sediment, aquatic invertebrates, and surface water pathways. Examples of the calculations are provided in the baseline report (Appendix 6.12-A).

For the purposes of this risk assessment, it is assumed that a 0.055-kg spotted sandpiper consumes 100% of its diet as invertebrates. Total ingestion rates of 0.0088 kg/d of food and 0.0085 L/d of water for shorebirds were estimated using BW scaling equations recommended by US EPA (1993). The ingestion rate of sediment for the shorebird was estimated at a conservative 3% of total food intake (US EPA 1993). Table 6.12.4-1 lists the exposure parameters for the spotted sandpiper.

6.12.4.1.1 Relevant Legislation and Legal Framework

The ERA has been completed according to accepted (ERA) methodologies and guidance published by BC MOE and associated guideline documents and referral agencies such as CCME (1996a, 1997) and US EPA (1998).

6.12.4.1.2 Spatial Boundaries

Spatial boundaries for the risk assessment correspond to the spatial boundaries of other environmental disciplines as necessary. The LSA and RSA identified for the assessment of the Birds VC were based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range, and activities that would bring the receptors into contact with various environmental media. In any population of organisms, there is extensive variability among individuals amongst each of these parameters. For birds, the LSA and RSA would be similar to that of the air quality study areas (Section 6.2), which defines the LSA as 2 km wide surrounding the proposed Project footprint and the RSA as

2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).

6.12.4.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project, which are contingent on permitting, include four primary phases:

1. Construction Phase – estimated 25-month period. This includes:
    - Site clearing and preparation, earthworks such as excavating and site grading;
    - Construction of mine site roads and power distribution lines on the site;
    - Facilities, such as processing plant, Tailings Management Facility (TMF) starter embankment, reclaim pipe works;
    - Camp complex; and
    - May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).
2. Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years would be spent milling low-grade ore). This includes progressive reclamation.
3. Decommissioning and Closure Phase – estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase – estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse effects on local receiving waters. Stabilisation of the WRMF and TMF will also be considered in post-closure monitoring.

6.12.4.2 Information Sources and Methods

Environmental chemistry data were obtained from other disciplines (i.e., water, air, soil, and vegetation) as necessary and compared to federal and provincial regulatory guidelines. Analytical chemistry data for soil and surface water were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2011), for residential / parkland land use;

- BC *CSR* of the BC *EMA*, Schedule 4 Generic Numerical Soil Standards, for park and residential land use; and
- BC "Surface Water Quality Guidelines" (Government of BC 2011).

Analytical chemistry data for sediment were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's "Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life" (CCME 2002); and
- "Criteria for Managing Contaminated Sediment Sites in British Columbia, Technical Appendix". (Government of BC 2002).

Ecological health risks were assessed by following Ecological Risk Assessment guidance recommended by BC MOE (1998), CCME (1996a, 1997), and US EPA (1998).

In order to evaluate the overall exposure of the human or ecological receptors to project-related emissions, mathematical models were used to predict changes in the COPC concentration in the different media from baseline conditions. The chemical composition of the surface waters in rivers and creeks forming the watershed in the vicinity of the proposed mine site can mainly be altered as a result of the surface run-off of chemicals from the site through drainage ditches or from the process-water outfall into any given water body. Chemicals in the surface water can be found in either the dissolved or suspended solid state. Atmospheric depositions can also add to the increase in COPC concentration in water bodies but its overall contribution is much smaller than direct intake from discharge lines or site run-off.

The situation is different for soil and vegetation. Atmospheric depositions (wet and dry) from project emissions are the only source of COPCs that can modify the soil chemical composition. Vegetation is affected by airborne emissions both through direct deposition and indirectly via uptake of deposited chemicals from the soil. For the Kitsault mine project, fugitive dust deposition modeling states that dust deposition along the haul road would be approximately 2.1 g/m^2/month five meters from the road, decreasing to 0.004 g/m^2/month within the LSA. These dust fall estimates are well below BC MOE objective of 8.7 g/m^2/month. Therefore, based on minimal atmospheric deposition, it is not expected that COPCs concentration in soil and vegetation surrounding the proposed mine site will be affected during the project phase.

6.12.4.3 Baseline Description of VC #3: Birds

The baseline report (Appendix 6.12-A) summarises the baseline health for birds in the vicinity of the proposed Project area. Raptors, songbirds, waterfowl, and shorebirds were assessed as receptors in the baseline study. Risks to birds were characterised by comparing the exposure estimates for each COPC to TRVs for each representative bird species. Risks to birds exposed to COPCs in all potential pathways have been characterised by comparing the weight-normalised exposure estimates for each COPC to

TRVs for the short-eared owl, American robin, loon, and spotted sandpiper. Toxicological information for the COPCs with respect to the receptors of concern (i.e., northern goshawk, sooty grouse, and olive-sided flycatcher) was not available; therefore, surrogates species such as the short-eared owl (instead of northern goshawk) and the American robin (instead of olive-sided flycatcher) were used in the baseline assessment because necessary toxicological information was available for these species. If no adverse health effects were noted for the surrogate species, then it was assumed that the VCs would not be adversely affected as well.

The baseline prediction was completed using site soils and water quality data as a representation of site conditions prior to commencement of proposed Project activities. The baseline data is intended to be compared to the effects assessment, which used water quality data modelled for the construction, operation, closure and decommissioning, and post-closure phases of the proposed Project.

Table 6.12.4-2 presents the baseline risk estimates for birds.

Table 6.12.4-2: Baseline Risk Estimates for Birds

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Short-eared owl			
Arsenic	0.000079	2.2	0.000035
Cadmium	0.000077	1.47	0.00005
Chromium	0.0005	1.0	0.0005
Molybdenum	0.024	3.5	0.007
Nickel	0.00097	77.4	0.000013
Selenium	0.000066	0.50	0.00013
American Robin			
Arsenic	0.15	2.2	0.07
Cadmium	0.15	1.47	0.10
Chromium	0.89	1.0	0.89
Molybdenum	0.52	3.5	0.15
Nickel	1.3	77.4	0.02
Selenium	0.027	0.50	0.05
Loon			
Arsenic	0.013	2.2	0.0057
Cadmium	0.015	1.47	0.01
Chromium	0.045	1.0	0.045
Molybdenum	0.035	3.5	0.01
Nickel	0.026	77.4	0.00033
Selenium	0.089	0.50	0.18

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Spotted Sandpiper			
Arsenic	1.23	2.2	0.56
Cadmium	1.15	1.47	0.79
Chromium	0.70	1.0	0.70
Copper	2.28	47.0	0.06
Lead	2.94	3.85	0.76
Mercury	0.0011	0.0064	0.17
Molybdenum	1.57	3.5	0.45
Nickel	1.74	77.4	0.023
Selenium	0.055	0.50	0.11

Note: COPC - Chemicals of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

6.12.4.4 Cultural Ecological or Community Knowledge

6.12.4.4.1 Nisg̱a'a Nation

The NFA defines Nisg̱a'a Nation rights to harvest migratory birds in accordance with conservation measures and public safety within the Nass Area, which overlaps with the proposed Kitsault mine site and transportation route. The Nisg̱a'a entitlement to the harvest of migratory birds must be "consistent with the communal nature of the Nisga'a harvest for domestic purposes" (BC MARR 2000). As with wildlife, the Nisg̱a'a Nation has the jurisdiction to enact laws regarding the methods, timing, sale, and licensing related to the harvest of migratory birds. The Nisg̱a'a Nation participates in management discussions and decisions about migratory birds within the Nass Wildlife Committee. The Crown also has the ability to authorise use of Crown land that can affect the methods, timing, and location of Nisg̱a'a migratory bird harvest as long as the Crown ensures that the activities "do not deny Nisg̱a'a citizens the reasonable opportunity to harvest migratory birds under Nisg̱a'a wildlife entitlements" (BC MARR 2000).

6.12.4.4.2 Aboriginal Groups

The five potentially affected groups, including Metlakatla First Nation, Kitsumkalum First Nation, Kitselas First Nation, Gitanyow Hereditary Chiefs, and Gitxsan Chiefs, have interests in birds for purposes of harvest, consumption and cultural regalia. In particular, Gitanyow Hereditary Chiefs value the Northern Goshawk. Kitselas First Nation hunt game birds in the fall and winter, primarily from September to November, and include species such as ruffed grouse, spruce grouse, blue grouse, Canada geese, and mallard ducks. Kitsumkalum members hunted birds regularly, including eagles, swans, geese, ducks, and other waterfowl.

6.12.4.5 Past, Present, or Future Projects / Activities That May Interact With VC #3

The current assessment evaluates future ecological health risks that potentially could be associated with the proposed Project relative to baseline conditions that, by definition, would include any past or present projects in the vicinity. The following will be considered for the assessment:

- **Historical land use,** including previous mining and exploration activities and construction of the Kitsault Townsite which is located 5 km from the proposed Project;
- **Current land use,** including nearby transportation and access roads, ongoing mining exploration, trapping and guide outfitting, marine boat traffic and recreational fishing; and
- **Future land use,** including the NTL Project.

6.12.4.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to environmental health since they could adversely affect the long-term health of bird populations and the role of different bird species in the ecosystem. Emphasis is placed on metals as the COPCs, since metals usually pose the most potential for adverse health risks at mines. Mining projects often have high metal concentrations and volumes in mining wastes and in dust generated from mining activities, which often persist in the environment. The environmental health component provides information, including chemical analyses, modelling results, and data through exposure modelling calculations, to assess effects on the health of birds.

6.12.4.6.1 Identification and Analysis of Potential Project Cumulative Effects

Ecological COPCs have been identified by screening the 95th percentile concentrations for soil, surface water, and sediment against CCME guidelines (or other toxicity-based guidelines as appropriate) and local background concentrations. Baseline soil concentrations have been collected, and have been used as the basis for the PQRA and the assessment completed presented in this section. The baseline is representative of the existing brownfield conditions and have been considered representative of soil conditions and COPCs concentrations at the time of proposed Project closure.. Proposed Project effects data for surface water for all Project phases were used for the assessment due to the availability of predictive modeling tools to assess the potential effects to surface water conditions. Chemicals have been assessed in the ERA if the 95th percentile concentration exceeded the relevant guideline, or the detection limit exceeded the guideline. The results of the COPC screening are summarised in Table 6.12.4-3 and 6.12.4-4.

Table 6.12.4-3: Screening of Chemicals of Potential Concern in Soil and Surface Water for Ecological Receptors

Metal COPC	Soil (mg/kg)			Surface Water (mg/L)		
	95th Percentile of Baseline Concentration (a)	Screening Guideline		95th Percentile of Surface Water Concentration (d)	Screening Guideline	
		CCME (b)	Government of BC (c)			Government of BC, Protection of Wildlife
Antimony	5.0	20	20	0.02		n/a
Arsenic	29.0	17	n/a	0.013		0.025 (f)
Barium	175.5	500	n/a	0.056		n/a
Beryllium	0.84	4	4	0.0007		n/a
Cadmium	0.97	10	n/a	0.0029		0.08 (h)
Chromium	97	64	n/a	0.001		0.05 (h)
Cobalt	26.2	50	50	0.00034		1 (h)
Copper	49.2	63	n/a	0.012		0.3 (f)
Lead	48.0	140	n/a	0.011		0.1 (h)
Mercury	0.25	6.6	n/a	0.00019		0.003 (h)
Molybdenum	94.9	10	10	1.6		0.05 (e)
Nickel	99.4	50	100	0.02		1 (h)
Selenium	1.4	1	3	0.015	0.004 (e)	0.004 (e)
Silver	7.2	20	20	0.00006	0.0015 (e)	n/a
Thallium	0.5	1	n/a	0.00011	0.0003 (h)	n/a
Vanadium	98.1	130	200	0.003	0.006 (h)	0.1 (h)
Zinc	163.5	200	n/a	0.065	0.033 (e)	2 (g)

Note: BC - British Columbia; CCME - Canadian Council of Ministers of the Environment; COPC - Chemical of Potential Concern; mg/kg - milligrams per kilogram; mg/L - milligrams per litre; n/a - not applicable (a) 95th percentile of baseline soil concentrations. Concentrations provided by Rescan and AMEC Soil Quality Group. (b) CCME Soil Quality Guideline for the Protection of Environmental Health (CCME 2011). Value represents guideline protective of residential / parkland uses. (c) *BC Environmental Management Act*, *Contaminated Sites Regulation*, Schedule 4 Numeric Soil Standards. (d) 95th percentile of project effects surface water concentrations (all project phases). Concentrations provided by AMEC Water / Sediment Quality Group. (e) BC Water Quality Guideline (30-day average) for the Protection of Wildlife (Government of BC 2011). (f) BC Water Quality Guideline (maximum) for the Protection of Wildlife (Government of BC 2011). (g) BC Water Quality Guideline (interim maximum) for the Protection of Wildlife (Government of BC 2011). (h) BC Water Quality Guideline (maximum) for the Protection of Livestock (surrogate for wildlife) (Government of BC 2011). Highlighted cell indicates metal is a COPC in specified medium for ecological risk assessment. Metal was selected as a COPC in soil if the 95th percentile of the baseline concentration exceeded screening guideline in soil; and in water if 95th percentile of the project effects (all phases) concentration exceeded screening guidelines in water.

For the purpose of the ERA, the assessment findings were compared to the CCME (2011) "residential / parkland" as conditions at the site as a result of the proposed Project activities are anticipated to be: primarily dominated by open, reclaimed, and re-contoured areas of shrubs and grasses, wooded areas and barren areas; and expected to provide habitat for ecological receptors. Table 6.12.4-4 identifies COPCs round in sediments in the proposed Project setting.

Table 6.12.4-4: Identification of COPC in Sediment

Parameter	95th Percentile Concentration (mg/kg)	Number of Samples Analysed	CCME		BC MOE		COPC
			ISQG	PEL	$SedQC_{TS}$	$SedQC_{SS}$	
Antimony	7.8	22	n/a	n/a	n/a	n/a	no
Arsenic	340	22	5.9	17	20	11	yes
Barium	299	22	n/a	n/a	n/a	n/a	no
Beryllium	2.1	22	n/a	n/a	n/a	n/a	no
Cadmium	14.5	22	0.6	3.5	4.2	2.2	yes
Chromium	88.7	22	37.3	90	110	56	yes
Cobalt	123	22	n/a	n/a	n/a	n/a	no
Copper	256	22	35.7	197	240	120	yes
Lead	420	22	35	91.3	110	57	yes
Mercury	0.3	22	0.17	0.486	0.58	0.3	yes
Molybdenum	377	22	n/a	n/a	n/a	n/a	no
Nickel	155	22	n/a	n/a	n/a	n/a	no
Selenium	4.1	22	n/a	n/a	n/a	n/a	no
Silver	8.8	22	n/a	n/a	n/a	n/a	no
Vanadium	70.3	22	n/a	n/a	n/a	n/a	no
Zinc	n/d	0	123	315	380	200	no

Note: BC MOE - British Columbia Ministry of Environment; CCME - Canadian Council of Ministers of the Environment; COPC - Chemical of Potential Concern; ISQG - Interim Sediment Quality Guidelines; mg/kg - milligrams per kilogram; n/a - not applicable; n/d - no data; PEL - Probable Effects Level; SED_{SS} - Sediment Quality Criteria for Sensitive Sites; SED_{TS} - Sediment Quality Criteria for Typical Sites

Screening for Soil

Analytical chemistry data for soil were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health" (CCME 2011), for residential / parkland land use; and

- BC *CSR* of the BC *EMA*, Schedule 4 Generic Numerical Soil Standards, for parkland and residential land use.

In the absence of a CCME guideline for a specific chemical, concentrations were screened against the BC *CSR*, Schedule 4 Generic Numerical Standards, assuming a residential / parkland land use. These criteria were developed to be protective of both environmental and human health.

Screening for Surface Water

The reported concentration data for surface water were assessed and evaluated for the purposes of identifying COPCs using:

- BC "Surface Water Quality Guidelines" (Government of BC 2011).

Screening for Sediments

Analytical chemistry data for sediment were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's "Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life" (CCME 2002); and
- "Criteria for Managing Contaminated Sediment Sites in British Columbia, Technical Appendix" (Government of BC 2002).

Baseline studies revealed that several inorganic contaminants exceeded the CCME Interim Freshwater Sediment Quality Guidelines (ISQG) and the Probable Effects Levels (PEL), BC Sediment Quality Criteria (SedQC). The following parameters exceeded the guidelines:

- Arsenic exceeded the ISQG of 5.9 mg/kg in all of the sediment samples;
- Cadmium exceeded the ISQG of 0.6 mg/kg in 19 of 22 sediment samples;
- Chromium exceeded the ISQG of 37.3 mg/kg in 20 of 22 sediment samples;
- Copper exceeded the ISQG of 35.7 mg/kg in 19 of 22 sediment samples;
- Lead exceeded the ISQG of 35.0 mg/kg in 16 of 22 sediment samples; and
- Mercury exceeded the ISQG of 0.17 mg/kg in 6 of 22 sediment samples.

Arsenic, cadmium, copper and lead concentrations in the sediments exceeded BC MOE SedQC for typical ($SedQC_{TS}$) and sensitive sites ($SedQC_{SS}$). Chromium concentrations in sediments exceeded the $SedQC_{SS}$. Both types of SedQCs are intended to identify the concentrations of COPCs below which risks to sediment-dwelling organisms are considered to be tolerable. Sediment criteria or guidelines for antimony, barium, beryllium, cobalt, molybdenum, nickel, selenium, silver and vanadium were not available and were not carried forward in the assessment.

Summary of Identified COPCs

Based on the screening conducted for soil concentrations (Table 6.12.4-3), the following chemicals were identified COPCs in soil and were carried forward in the ERA for the proposed Project:

- Arsenic;
- Chromium;
- Molybdenum;
- Nickel; and
- Selenium.

The remaining COPCs found in soil were below their respective guidelines and have not been carried forward in the assessment.

Based on the screening conducted for surface water concentrations (Table 6.12.4-3), molybdenum and selenium compounds were identified as COPCs in surface water and have been carried forward in the ERA for the proposed Project:

The remaining COPCs found in surface water were below their respective guidelines for aquatic and wildlife health and have not carried forward in the assessment.

Based on the screening conducted for sediment concentrations (Table 6.12.4-4), the following compounds were identified COPCs in sediment and have been carried forward in the ERA for the proposed Project:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Lead; and
- Mercury.

The remaining COPCs found in sediments are below their respective guidelines and have not been carried forward in the assessment.

Exposure Assessment

The exposure assessment includes an analysis of the pathways through which VCs may be exposed to COPCs and an estimate of the concentrations to which they may be exposed. For COPCs to have deleterious effects on ecological receptors, the COPC must have contact with the organism or receptor. The route by which this occurs is referred to as an exposure pathway and is dependent on the nature of the chemical and the nature of the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of COPCs must be present;
- Release and transport mechanisms and media must be available to move the COPC from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the COPC is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

Pathway Analysis

Incidental Soil Ingestion

Wildlife can be exposed to contaminants in soil via several pathways, including ingestion and dermal contact. While both pathways can potentially result in uptake depending on the properties of the chemical, the predominant pathway for birds is usually through ingestion. The presence of feathers limits the amount of contact that chemicals have with skin; soil adhered to fur is ultimately ingested during grooming (Sample and Suter 1994).

Soil comprises a small fraction of the diet for many organisms; the actual quantity of soil ingested depends on the life history traits of the species. A major source of soil ingested by birds is soil adhered to the surface and the gut of prey items. Quantities of soil ingested from these different sources are not typically distinguished; rather, exposure is quantified through the estimation of the average overall soil consumption (as a fraction of diet) for each species.

Although the COPCs may be consumed by an organism, only a fraction is absorbed through the gut and is available to cause toxicity. This uptake depends on a number of site-specific and organism-specific factors, which complicates the ability to define actual exposures. Therefore, for the purposes of this risk assessment, it is assumed that the entire quantity of COPCs in the soil consumed by birds is bioavailable and can potentially result in adverse effects.

Ingestion of Food / Prey

Birds such as the sooty grouse can also be exposed to COPCs in the soil via consumption of vegetation (e.g., leaves), which may have bio-accumulated COPCs from the soils. Plants growing in soils containing elevated concentrations of chemicals may accumulate and can potentially distribute those chemicals to portions of the plant consumed. Similarly, soil invertebrates in contact with contaminated soil can accumulate metals which can be assimilated by olive-sided flycatcher upon consumption.

Ingestion of Aquatic Invertebrates

Shorebirds may be exposed to COPCs via ingestion of invertebrates which have accumulated contaminants from sediment. The level to which contaminants accumulate in invertebrates is a function of the physicochemical properties of the COPC, the rate of uptake into invertebrate tissue, and the ability of the COPC to be sequestered, metabolised, or otherwise eliminated. In general, metals are not accumulated to a significant degree compared to other COPCs, because uptake is strongly regulated, and organisms sequester or eliminate metals through various pathways. Therefore, ecological receptors can be exposed to metals through ingestion of invertebrates.

Bioaccumulation and Biomagnifications in Terrestrial and Aquatic Organisms

Ecological receptors at the top of the food web (e.g., piscivorous birds) are susceptible to adverse effects as a result of consuming prey that have accumulated these compounds. Biomagnification occurs when the following conditions occur at all trophic levels:

- Contaminant is ingested as food;
- Transformation is not significant;
- Elimination rate is low; and
- Transfer occurs at several trophic levels.

Contaminants that bioaccumulate in fish are potentially available for uptake by consumers of fish. Exposure to these chemicals via consumption of fish is a relevant exposure pathway for piscivorous avian species. As uptake can vary from site to site due to differences in sediment chemistry, the best estimate of metal content is achieved by sampling and measuring metal content in tissues.

Exposure Estimates

Exposure estimates are provided for birds with complete exposure pathways. The exposure estimates are presented as weight-normalised daily doses. An ADD (in units of mg/kg/d) is calculated by summing the exposure doses for each exposure pathway. Examples of the calculated ADD of COPCs for birds were provided in the baseline report (Appendix 6.12-A). The 95th percentile concentrations in each environmental media were used to determine the ADD for birds (Table 6.12.4-5).

Table 6.12.4-5: Ecological Risk 95th Percentile Concentrations

Metal COPC	95th Percentile Surface Water Concentration (mg/L)	95th Percentile Soil Concentration (mg/kg)	95th Percentile Plant Tissue Concentration (mg/kg)	95th Percentile Fish Concentration (mg/kg)	95th Percentile Sediment Concentration (mg/kg)
Arsenic	0.0129	29.0	0.025	0.13	340.3
Cadmium	0.0029	n/a	n/a	0.15	14.5
Chromium	0.0015	97.0	0.50	n/a	88.7
Copper	0.012	n/a	n/a	0.73	255.7
Lead	0.011	n/a	n/a	0.1	419.7
Mercury	0.00019	n/a	n/a	0.07	0.3
Molybdenum	1.61	95.0	1.4	0.03	n/a
Nickel	0.028	99.5	1.7	0.26	n/a
Selenium	0.016	1.4	0.50	0.89	n/a
Zinc	0.065	n/a	n/a	16.4	n/a

Note: COPC - Chemicals of Potential Concern; mg/kg - milligrams per kilograms; mg/L - milligrams per litre; n/a - not applicable

Toxicity Assessment

The following details the potential adverse effects on birds associated with exposure to COPCs. For each bird, TRVs representing concentrations of COPCs in the various environmental media that would not result in adverse health effects were identified.

Arsenic

The clinical effects of arsenic toxicity in avian species is similar to that in mammals, but birds in general are more sensitive to the adverse effects of arsenic. The TRV for birds was based on studies collated by US EPA (2005). Recent research suggests that physiological scaling factors developed for mammals may not be appropriate for interspecies extrapolation among birds (Sample et al. 1996). Therefore, the adopted TRV for the olive-sided flycatcher, sooty grouse, northern goshawk, loon, and spotted sandpiper is 2.24 mg/kg/d.

Cadmium

The main routes of cadmium absorption in birds are via ingestion. Factors that are reported to affect dietary cadmium absorption from the gastrointestinal tract include age, sex, chemical form, level of protein, levels of calcium, and the presence of other elements (Nriagu 1981). Cadmium-induced effects associated with oral intake include nephrotoxicity and also possible effects on the liver, reproductive organs, and the hematopoietic, immune, skeletal, and cardiovascular systems (Shore and Douben 1994). The TRV for birds was based on studies collated by US EPA (2005). Shorebirds (i.e., spotted sandpiper) are the only bird species in the assessment that are potentially exposed to cadmium via uptake of sediment during ingestion of aquatic invertebrates. The adopted TRV for the spotted sandpiper is 1.47 mg/kg/d.

Chromium

The clinical effects of chromium in avian species are similar to that in mammals. Recent research suggests that physiological scaling factors developed for mammals may not be appropriate for interspecies extrapolation among birds (Sample et al. 1996). The adopted TRV for the olive-sided flycatcher, sooty grouse, northern goshawk, loon, and spotted sandpiper is based on Sample et al. (1996) LOAEL of 5 mg/kg/d.

Copper

Copper is essential for hemoglobin formation, carbohydrate metabolism, catecholamine biosynthesis, and cross-linking of collagen, elastin, and hair keratin (US EPA 1987). The primary route of exposure to copper in birds is through ingestion. Generally, the normal intake of copper by inhalation is a negligible fraction of the total (Friberg et al. 1986), and absorption through the skin is minimal (Venugopal and Luckey 1978). Shorebirds (i.e., spotted sandpiper) are the only bird species in the assessment that are potentially exposed to copper via uptake of sediment during ingestion of aquatic invertebrates. The TRV for shorebirds was based on studies collated by US EPA (2005). The adopted TRV for shorebirds is 47 mg/kg/d.

Lead

Clinical signs of lead toxicity in birds are manifested differently for different species, but the overall signs are of encephalopathy preceded and accompanied by gastrointestinal malfunction (Booth and MacDonald 1982). Behavourial signs of toxicity include anxiety, apprehension, hyperexcitability, vocalisation, rolling of eyes, apparent fear or terror, possible belligerence, pressing of the head against a wall or post, attempts to climb a wall, sudden jumping into the air, frenzied or maniacal behaviour (Booth and MacDonald 1982). Locomotor disturbances of lead poisoning range from a stiff, stilted gait with ataxia and incoordination to rigidity of all postural muscles, swaying, and posterior weakness to compulsive hypermotility (i.e., circling, pacing, and running) (Booth and MacDonald 1982). Shorebirds (i.e., spotted sandpiper) are the only bird species in the assessment that are potentially exposed to lead via uptake of sediment during ingestion of aquatic invertebrates. The TRV for shorebirds was based on studies collated by US EPA (2005). The adopted TRV for the shorebirds exposed to lead is 3.85 mg/kg/d.

Mercury

Birds may be exposed to chronic low levels of mercury present in the environment. There are numerous effects in birds, including delayed testicular development, altered mating behaviour, reduced fertility and reduced survivability and growth in young (ATSDR 1994). Shorebirds (i.e., spotted sandpiper) are the only bird species in the assessment that are potentially exposed to mercury via uptake of sediment during ingestion of aquatic invertebrates. The TRV for shorebirds was based on studies collated by US EPA (2005). The adopted TRV for shorebirds exposed to mercury is 0.0064 mg/kg/d.

Molybdenum

Recent research suggests that physiological scaling factors developed for mammals may not be appropriate for interspecies extrapolation among birds (Sample et al. 1996). The adopted TRV for the olive-sided flycatcher, sooty grouse, northern goshawk, loon and spotted sandpiper is 3.5 mg/kg/d (Sample et al. 1996).

Nickel

Recent research suggests that physiological scaling factors developed for mammals may not be appropriate for interspecies extrapolation among birds (Sample et al. 1996). The adopted TRV for the olive-sided flycatcher, sooty grouse, northern goshawk, loon and spotted sandpiper is 77.4 mg/kg/d (Sample et al. 1996).

Selenium

The clinical effects of selenium in avian species are similar to that in mammals, but birds in general are more sensitive to the effects of selenium. Recent research suggests that physiological scaling factors developed for mammals may not be appropriate for interspecies extrapolation among birds (Sample et al. 1996). The adopted TRV for the olive-sided flycatcher, sooty grouse, northern goshawk, loon and spotted sandpiper is 0.5 mg/kg/d (Sample et al. 1996).

Risk Characterisation

ERs are a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure Ratio} = \frac{\text{Exposure Estimate}}{\text{TRV}}$$

ERs are interpreted as follows:

If the ER is less than 1, no unacceptable risks to birds would be expected, because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds 1, it may be inferred that adverse effects to individuals are possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV that was based on a 25% reduction in a growth-based endpoint (ER>1), it can be inferred that one possible outcome may be diminished growth of individuals in a population. This can potentially (but not necessarily) lead to a reduction in population abundance of that receptor. It is important to note that exceeding an ER of 1 does not necessarily mean that adverse effects will definitively occur; rather, it suggests that we have less confidence that adverse effects will not occur. It is also important to recognise that the magnitude of ERs is not directly associated with the magnitude of potential effects. That is, a large ER (>10) should not be interpreted as a 10-fold greater risk than an ER of 1.

For those COPCs with ERs greater than 1, potential risks at a population level cannot be ruled out and should be evaluated further. Evidence from sources other than chemical analysis may be employed, including evidence of toxicity at the proposed Project site, toxicity of media in laboratory exposures (i.e., bioassays), the absence of species formerly present or commonly found at similar sites, or diminished populations compared to a reference location.

Quantitative Interpretation of Risk Hazard

Risks to birds exposed to COPCs in all potential pathways were characterised by comparing the weight-normalised exposure estimates for each COPC to TRVs for the northern goshawk, olive-sided flycatcher, sooty grouse, common loon, and spotted sandpiper. The ERs for all COPCs were below 1 for the northern goshawk, olive-sided flycatcher, sooty grouse, and common loon. The ER for cadmium and lead exceeded 1 for the spotted sandpiper while the ERs for the remaining COPCs were below 1.Risk estimates for birds are presented in Table 6.12.4-6.

Table 6.12.4-6: Risk Estimates for Birds

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Northern Goshawk			
Arsenic	0.0068	2.2	0.0031
Chromium	0.037	5.0	0.0073
Molybdenum	0.11	3.5	0.032
Nickel	0.055	77.4	0.00071
Selenium	0.0022	0.50	0.0043
Olive-Sided Flycatcher			
Arsenic	0.24	2.2	0.11
Chromium	1.4	5.0	0.28
Molybdenum	1.1	3.5	0.31
Nickel	2.1	77.4	0.027
Selenium	0.046	0.50	0.091
Sooty Grouse			
Arsenic	0.047	2.2	0.021
Chromium	0.16	5.0	0.031
Molybdenum	0.24	3.5	0.069
Nickel	0.16	77.4	0.0021
Selenium	0.0039	0.50	0.0078
Common Loon			
Arsenic	0.053	2.2	0.024
Chromium	0.016	5.0	0.0032
Molybdenum	0.061	3.5	0.017
Nickel	0.010	77.4	0.00013
Selenium	0.032	0.50	0.065
Spotted Sandpiper			
Arsenic	1.96	2.2	0.87
Cadmium	1.79	1.47	1.22
Chromium	1.09	5.0	0.22
Copper	4.46	47.0	0.095
Lead	4.57	3.85	1.19
Mercury	0.0017	0.0064	0.27
Molybdenum	2.64	3.5	0.75
Nickel	2.71	77.4	0.035
Selenium	0.087	0.50	0.17

Note: COPC - Chemicals of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

6.12.4.7 Limitations

Assessing health risks from environmental chemicals is always associated with uncertainty. Where there is uncertainty, conservative assumptions have been used to ensure that risks have not been underestimated (and in fact almost certainly overestimated). In the exposure assessment, uncertainty relate to the assumptions regarding the presence of VCs. Conservative assumptions have been made to ensure any ecological receptors that might be present in the vicinity of the proposed Project site are provided sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, which is why there is some uncertainty associated with toxicity reference values. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs). This is because most reference values are based on the most sensitive species tested or a similar low effect level (e.g., 10^{th} or 25^{th} percentile of species sensitivity distribution). Further, toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e. the use of soluble metal salts).

COPCs emissions data were not available for this assessment. Emissions data can be an important component of a risk assessment as it can be a key pathway for the dispersion of COPCs. Air dispersion modeling for COPCs concentrations for baseline and proposed Project effects was not completed for the ERA (Appendix 6.12-A). Long-term ambient monitoring at near-by sites has not been implemented because of lack of anthropogenic activities, the remote location and its difficult access, and likely ultra-low concentrations of CACs which are anticipated to be below the detection limit of a typical portable monitoring station. Developing background concentration by means of air dispersion modelling is also not feasible for the proposed Project because of a lack of specific emission sources. Baseline data for most exposure media pathways (i.e., soil, vegetation, berries) were used because proposed Project effects data were unavailable for the ERA. Proposed Project effects data were used when available (i.e., surface water data).

For risk characterisation, the ERs generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring. There is greater inherent uncertainty associated with results of screening level assessments than higher-tier assessments, because results are based primarily on modelled or estimated concentrations and TRVs derived from literature studies, rather than direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure were made and no toxicity studies were performed. In many cases, toxicity at a site is considerably diminished compared to effects predicted from laboratory studies, for a variety of reasons. Higher-tier assessments (i.e., Preliminary Quantitative ERA) incorporate site-specific toxicity data in a lines-of-evidence approach, which can reduce the level of uncertainty in this phase of the assessment.

6.12.4.8 Conclusion

Risks to birds exposed to COPCs in all potential pathways were characterised by comparing the weight-normalised exposure estimates for each COPC to TRVs for the northern goshawk, olive-sided flycatcher, sooty grouse, common loon, and spotted sandpiper. The ERs for all COPCs were below 1 for the northern goshawk, olive-sided flycatcher, sooty grouse, and common loon. The ER for cadmium and lead exceeded 1 for the spotted sandpiper while the ERs for the remaining COPCs were below 1 as shown in Table 6.12.4-6

Risk estimates for the proposed Project differ from the baseline. For some birds, ERs for certain COPCs were higher in the effects assessment (Table 6.12.4-6) when compared to the baseline (Table 6.12.4-2). Available proposed Project effects data used in the ERA were limited to surface water only and may have contributed in the change in ERs from the baseline assessment to the effects assessment. Different exposure pathways (i.e., ingestion of birds) and characteristics (i.e., bodyweight) have also been applied to the effects assessment, which may have resulted in ER changes.

6.12.5 VC #4: Amphibians

6.12.5.1 Introduction

Amphibians have been included as a VC to address concerns that their health could be adversely affected by chemicals introduced to or mobilised in the environment as a result of the proposed Project. The Western toad has been selected as a surrogate species and is used in the assessment.

Western Toad

Western toads (*Anaxyrus boreas*) use three different types of habitat: breeding habitats; terrestrial summer range; and winter hibernation sites. Breeding sites consist of permanent or temporary water bodies. After breeding, Western toads disperse into terrestrial habitats. They may roam far, but they prefer damp conditions. Western toads spend much time underground in small mammal burrows below the frost line, and use them for hibernation (Government of BC 2011b).

The Western toad is found in the vicinity of the proposed Project and has been assessed as a receptor because amphibians have been identified as VCs and because of their distinct diet and importance in the ecosystem. It is assumed that if risks were acceptable for a typical Western toad, then risks would be acceptable for all amphibians.

Western toads are potentially exposed to elevated concentrations of metals in surface water and soil; therefore, exposure estimates for amphibians are based on the 95th percentile concentrations in soil and surface water collected.

6.12.5.1.1 Relevant Legislation and Legal Framework

The ERA has been completed according to accepted (ERA) methodologies and guidance published by regulatory agencies including CCME (1996a, 1997), BC MOE (1998), and US EPA (1998).

6.12.5.1.2 Spatial Boundaries

Spatial boundaries for the risk assessment correspond to the spatial boundaries of other environmental disciplines as necessary. The LSA and RSA are based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range, and activities that would bring the receptor into contact with various environmental media. In any population of organisms, there is extensive variability among individuals for each of these parameters. For amphibians, the LSA and RSA would be similar to that of the air quality study areas. The air quality discipline (Section 6.2) defines the LSA as 2 km wide surrounding the proposed Project footprint and the RSA as 2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).

6.12.5.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project which are contingent on permitting include four primary phases:

1. Construction Phase - estimated 25 month period. This includes:
   - Site clearing and preparation, earthworks such as excavating and site grading;
   - Construction of mine site roads and power distribution lines on the site;
   - Facilities, such as processing plant, TMF starter embankment, reclaim pipe works;
   - Camp complex; and
   - May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).
2. Operations Phase - estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years are milling low grade ore). This includes progressive reclamation.
3. Decommissioning and Closure Phase - estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase - estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse

effects on local receiving waters. Stabilisation of the WRMF and TMF will also be considered in post-closure monitoring.

6.12.5.2 Information Sources and Methods

Environmental chemistry data were obtained from other disciplines (i.e., water, air, soil, and vegetation) as necessary and compared to federal and provincial regulatory guidelines. Analytical chemistry data for soil and surface water were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2011), for residential / parkland land use;
- BC *CSR* of the BC *EMA*, Schedule 4 Generic Numerical Soil Standards, for park and residential use;
- BC "Surface Water Quality Guidelines" (Government of BC 2011); and
- Ecological health risks were assessed by following Ecological Risk Assessment guidance materials recommended by the BC MOE (1998), CCME (1996a, 1997), and US EPA (1998).

This section has assessed potential risks from metals associated with the proposed Project to amphibian receptors. Seventeen metals have been identified as potentially affecting soil or water relative to baseline conditions. Twelve of the 17 metals were immediately excluded as COPCs because their 95th percentile concentrations were less than their respective risk-based screening guidelines (set by the Government of BC, HC, and CCME) that are conservatively set to be protective of ecological health, regardless of exposure scenario. Five of the 17 metals have been included as COPCs for the risk assessment using site-specific exposure assumptions because their 95th percentile concentrations were greater than their respective risk-based screening guidelines.

However, the conservative approach taken to establish each screening guideline is such that an exceedance of the guideline does not necessarily mean there may be an unacceptable health risk.

In order to evaluate the overall exposure of the human or ecological receptors to project-related emissions, mathematical models were used to predict changes in the COPC concentration in the different media from baseline conditions. The chemical composition of the surface waters in rivers and creeks forming the watershed in the vicinity of the proposed mine site can mainly be altered as a result of the surface run-off of chemicals from the site through drainage ditches or from the process-water outfall into any given water body. Chemicals in the surface water can be found in either the dissolved or suspended solid state. Atmospheric depositions can also add to the increase in COPC concentration in water bodies but its overall contribution is much smaller than direct intake from discharge lines or site run-off.

The situation is different for soil and vegetation. Atmospheric depositions (wet and dry) from project emissions are the only source of COPCs that can modify the soil chemical composition. Vegetation is affected by airborne emissions both through direct deposition and indirectly via uptake of deposited chemicals from the soil. For the Kitsault mine project, fugitive dust deposition modeling states that dust deposition along the haul road would be approximately 2.1 g/m^2/month five meters from the road, decreasing to 0.004 g/m^2/month within the LSA. These dust fall estimates are well below BC MOE objective of 8.7 g/m2/month. Therefore, based on minimal atmospheric deposition, it is not expected that COPCs concentration in soil and vegetation surrounding the proposed mine site will be affected during the project phase.

6.12.5.3 Baseline Description of VC #4: Amphibians

The Environmental Health Baseline Report (Appendix 6.12-A) summarises the baseline results of risks from the proposed Project to health of amphibians. Toxicological information for the COPCs with respect to the receptor of concern was not available. Therefore, a surrogate species such as the spotted frog was assessed as a receptor instead of the Western toad in the baseline study.

The baseline assessment was completed using site soils and water quality data to represent conditions prior to the onset of the proposed Project. The effects assessment presents the difference between the baseline assessment data and the effects assessment that used water quality data modelled for the construction, operations and closure / decommissioning of the proposed Project.

Risks to the spotted frog have been characterised by comparing the exposure estimates for each COPC to TRVs for the spotted frog. ERs for all COPCs are below 1 for amphibians. No adverse effects have been predicted for amphibians (Table 6.12.5-1).

Table 6.12.5-1: Baseline Risk Estimates for Amphibians

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Cadmium	0.0010	0.044	0.023
Molybdenum	0.32	0.96	0.33

Note: COPC - Chemical of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

6.12.5.4 Cultural Ecological or Community Knowledge

6.12.5.4.1 Nisga'a Nation

The NFA defines Nisga'a Nation rights to harvest wildlife, which includes amphibians. There is no other reference in the NFA regarding amphibians. Desk-based research and engagement activities with NLG did not indicate any specific concern or issue with amphibians. Ongoing consultation with NLG may provide additional information and insight into the value and interests of the health of amphibians related to the proposed Project.

6.12.5.4.2 Aboriginal Groups

Desk-based research and engagement activities with potentially affected Aboriginal groups did not indicate any specific concern or issue with amphibians. Ongoing consultation with Aboriginal groups may provide additional information and insight into the value and interests of the health of amphibians related to the proposed Project.

6.12.5.5 Past, Present, or Future Projects / Activities That May Interact With VC #4

The current assessment analyses future ecological health risks potentially associated with the proposed Project relative to baseline conditions, which, by definition, would include any past or present projects in the vicinity. The following will be considered for the assessment;

- **Historical land use,** including previous mining and exploration activities and construction of the Kitsault Townsite, which is located 5 km from the proposed Project;
- **Current land use,** including nearby transportation and access roads, ongoing mining exploration, trapping and guide outfitting, marine boat traffic, and recreational fishing; and
- **Future land use,** including the NTL Project.

6.12.5.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to the environmental health discipline since they could adversely affect the long-term health of amphibians. Emphasis is placed on identifying metals as COPCs, since metals usually pose the most potential for adverse health risks at mines. Mining projects often have high metal concentrations and volumes in mining wastes and dust generated from mining activities. High metal concentrations often persist in the environment. The environmental health component provides information, including chemical analyses and modelling results, and data through exposure modelling calculations to assess effects on the health of amphibians.

6.12.5.6.1 Identification and Analysis of Potential Project Effects

Ecological COPCs were identified by screening the 95th percentile concentrations for soil and surface water against CCME environmental health guidelines (or other toxicity-based guidelines as appropriate) and local background concentrations. Baseline soil concentrations were used to screen for the COPCs because proposed Project effects data are not available for the assessment. Predictions regarding whether the proposed Project will have an effect on the health of amphibians are not possible, since Project concentrations for soil are currently unavailable. Instead, proposed Project effects data for surface water for all Project phases have been used for the assessment. Chemicals have been assessed in the ERA if the 95th percentile concentration has exceeded the relevant guideline, or the detection limit has exceeded the guideline. The results of the COPC screening for soil and surface water are summarised in Table 6.12.5-2.

Table 6.12.5-2: Screening of Chemicals of Potential Concern in Soil and Surface Water for Ecological Receptors

Metal COPCs	Soil (mg/kg)			Surface Water (mg/L)	
	95th Percentile of Baseline Concentration (a)	Screening Guideline		95th Percentile of Surface Water Concentration (d)	Screening Guideline
		CCME (b)	Government of BC (c)		Government of BC, Protection of Wildlife
Antimony	5.0	20	20	0.02	n/a
Arsenic	29.0	17	n/a	0.013	0.025 (f)
Barium	175.5	500	n/a	0.056	n/a
Beryllium	0.84	4	4	0.0007	n/a
Cadmium	0.97	10	n/a	0.0029	0.08 (h)
Chromium	97	64	n/a	0.001	0.05 (h)
Cobalt	26.2	50	50	0.00034	1 (h)
Copper	49.2	63	n/a	0.012	0.3 (f)
Lead	48.0	140	n/a	0.011	0.1 (h)
Mercury	0.25	6.6	n/a	0.00019	0.003 (h)
Molybdenum	94.9	10	10	1.6	0.05 (e)
Nickel	99.4	50	100	0.02	1 (h)
Selenium	1.4	1	3	0.015	0.004 (e)
Silver	7.2	20	20	0.00006	n/a
Thallium	0.5	1	n/a	0.00011	n/a
Vanadium	98.1	130	200	0.003	0.1 (h)
Zinc	163.5	200	n/a	0.065	2 (g)

Note: BC - British Columbia; CCME - Canadian Council of Ministers of the Environment; COPC - Chemical of Potential Concern; mg/kg - milligrams per kilogram; n/a - not applicable (a) 95th percentile of baseline soil concentrations. Concentrations provided by Rescan and AMEC Soil Quality Group. (b) CCME Soil Quality Guideline for the Protection of Environmental Health (CCME 2011). Value represents guideline protective of residential / parkland uses. (c) *BC Environmental Management Act*, *Contaminated Sites Regulation*, Schedule 4 Numeric Soil Standards. (d) 95th percentile of project effects surface water concentrations (all project phases). Concentrations provided by AMEC Water / Sediment Quality Group. (e) BC Water Quality Guideline (30-day average) for the Protection of Wildlife (Government of BC 2011). (f) BC Water Quality Guideline (maximum) for the Protection of Wildlife (Government of BC 2011). (g) BC Water Quality Guideline (interim maximum) for the Protection of Wildlife (Government of BC 2011). (h) BC Water Quality Guideline (maximum) for the Protection of Livestock (surrogate for wildlife) (Government of BC 2011). Highlighted cell indicates metal is a COPC in specified medium for ecological risk assessment. Metal was selected as a COPC in soil if the 95th percentile of the baseline concentration exceeded screening guideline in soil; and in water if 95th percentile of the project effects (all phases) concentration exceeded screening guidelines in water..

Screening for Soil

Analytical chemistry data for soil have been assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2011), for residential / parkland land use; and
- BC *CSR* of the BC *EMA*, Schedule 4 Generic Numerical Soil Standards, for parkland and residential land use.

In the absence of a CCME guideline for a specific chemical, concentrations were screened against the BC *CSR*, Schedule 4 Generic Numerical Standards, assuming a residential / parkland land use. These criteria were developed to protect environmental health.

Screening for Surface Water

The reported concentration data for surface water were assessed and evaluated for the purposes of identifying COPCs using:

- BC "Surface Water Quality Guidelines" (Government of BC 2011).

Summary of Identified COPCs

Based on the screening conducted for soil concentrations (Table 6.12.3-2), the following compounds were identified COPCs in soil for amphibians and were carried forward in the ERA for the proposed Project:

- Arsenic;
- Chromium;
- Molybdenum;
- Nickel; and
- Selenium

The remaining COPCs found in soil were below their respective guidelines and have not been carried forward in the assessment.

Based on the screening conducted for surface water concentrations (Table 6.12.3-2), molybdenum and selenium have been identified as COPCs in surface water for amphibians and have been carried forward in the ERA for the proposed Project:

The remaining COPCs found in surface water were below their respective guidelines for wildlife health and have not been carried forward in the assessment.

Exposure Assessment

The exposure assessment includes an analysis of the pathways through which VCs may be exposed to COPCs and an estimate of the concentrations to which they may be exposed. For COPCs to have deleterious effects on ecological receptors, the COPC must have contact with the organism or receptor. The route by which potential exposure to COPCs occurs is referred to as an exposure pathway and is dependent on the nature of the chemical and the nature of the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of COPCs must be present;
- Release and transport mechanisms and media must be available to move the COPC from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the COPC is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

Pathway Analysis

Direct Soil Contact

Given the distribution of metals in soil at the site, exposure of amphibians to COPCs via direct contact with contaminated soil was assumed to be a complete exposure pathway in the ERA.

Direct Exposure to COPCs in Surface Water

Metals in surface water can exist in several forms, most commonly in dissolved forms or absorbed to suspended particulates. Metals dissolved in surface water readily bind to respiratory surfaces and induce adverse effects in amphibians. It is generally accepted that toxicological effects are most closely associated with the dissolved fraction of metals, and most toxicological models assume metals must be in solution to induce toxicity. Nevertheless, in practical terms this has little bearing on the evaluation of exposure in an ERA, as aqueous toxicological data is, in almost all cases, simply related to total metal concentration.

Exposure Estimates

The 95th percentile concentrations in each environmental media used for amphibians is presented in Table 6.12.5-3.

Table 6.12.5-3: Ecological Risk 95th Percentile Concentrations Used for Amphibians

Metal COPC	95th Percentile Surface Water Concentration (mg/L)	95th Percentile Soil Concentration (mg/kg)
Arsenic	n/a	29.0
Chromium	n/a	97.0
Molybdenum	n/a	95.0
Nickel	0.028	99.5
Selenium	0.015	1.4

Note: COPC - Chemical of Potential Concern; n/a- not applicable; mg/kg - milligrams per kilogram; mg/L - milligrams per litre

Toxicity Assessment

Ideally, risks would be characterised by comparing 95th percentile of COPCs in soil and surface water directly to soil and water-specific TRVs for amphibians. However, toxicity data for amphibians exposed to metals in soil and surface water are extremely limited. Reviews of scientific literature identified no chronic toxicity limits for amphibians exposed to arsenic, chromium, molybdenum, nickel, and selenium in soil and molybdenum and selenium in water.

In the case for soil, the Naval Facilities Engineering Service Center (NFESC) Amphibian Ecological Risk Assessment Guidance Manual was consulted for sediment screening levels for amphibians (ENSR International 2004), which would be used as applicable assessment criteria for risks due to soil exposures. ENSR International (2004) explicitly recommends that generic published screening levels for benthic invertebrates should be used preferentially for assessment of amphibians. However, it must be noted that screening values for benthic invertebrates are considered conservative for the protection of amphibians. In addition to the lack of toxicity values intended to protect amphibians, screening sediment guidelines that do not protect benthic invertebrates will also be considered to protect amphibians.

For amphibians, TRVs representing concentrations of COPCs in the various environmental media that would not result in adverse health effects are presented in Table 6.12.5-4:

Table 6.12.5-4: TRVs for Amphibians

Metal COPC	TRV for Soil (mg/kg) (a)	TRV for Surface Water (mg/L) (b)
Arsenic	20	n/a
Chromium	110	n/a
Molybdenum	n/a	n/a
Nickel	n/a	n/a
Selenium	n/a	n/a

Note: COPC - Chemical of Potential Concern; mg/kg - milligrams per kilogram; mg/L - milligrams per litre; n/a - not applicable (a) TRV is based on BC MOE-British Columbia Ministry of Environment SED_{TS}-Sediment Quality Criteria for Typical Sites. (b) No toxicological data for surface water is available for amphibians

Arsenic

The BC MOE's SED_{TS} of 20 mg/kg was adopted as the TRV for amphibians exposed to COPCs in soil (Government of BC 2002). This guideline is intended to protect benthic invertebrates, but for the purpose of this ERA, it will also be considered protective of amphibians. TRVs for amphibians exposed to COPCs in surface water were not available.

Chromium

The BC MOE's SED_{TS} of 110 mg/kg was adopted as the TRV for amphibians exposed to COPCs in soil (Government of BC 2002). This guideline is intended to protect benthic invertebrates, but for the purpose of this ERA, it will also be considered to protect amphibians, TRVs for amphibians exposed to COPCs in surface water were not available.

COPCs with sediment screening values were carried forward in the ERA for amphibians while the remaining COPCs with no available screening guidelines were considered as uncertainties in the assessment.

Risk Characterisation

ERs are a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure Ratio} = \frac{\text{Exposure Estimate}}{\text{TRV}}$$

ERs are interpreted as follows:

If the ER is less than 1, no unacceptable risks to amphibians would be expected because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds 1, it may be inferred that adverse effects to individuals are possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV that was based on a 25% reduction in a growth-based endpoint (ER>1), it can be inferred that one possible outcome may be diminished growth of individuals in a population. This can potentially (but not necessarily) lead to a reduction in population abundance of that receptor. It is important to note that exceeding an ER of 1 does not necessarily mean that adverse effects will definitively occur; rather, it suggests that there is a lower confidence that adverse effects will not occur. It is also important to recognise that the magnitude of ERs is not directly associated with the magnitude of potential effects. That is, a large ER (>10) should not be interpreted as a 10-fold greater risk than an ER of 1.

For those COPCs with ERs greater than 1, potential risks at a population level cannot be ruled out and should be evaluated further. Evidence from sources other than chemical analysis may be employed, including evidence of toxicity at the proposed Project site, toxicity of media in laboratory exposures (i.e., bioassays), the absence of species formerly present or commonly found at similar sites, or diminished populations compared to a reference location.

Quantitative Interpretation of Risk Hazard

ERs for amphibians exposed to COPCs in soil have been characterised by comparing the exposure estimates for each COPC to the adopted TRVs for the Western toad. ERs for arsenic exceed 1 while the ERs for chromium were below 1. Risk estimates are presented in Table 6.12.5-5.

Table 6.12.5-5: Risk Estimates for Amphibians

COPC	Exposure Estimate (mg/kg/d) (a)	TRV (mg/kg/d) (b)	Exposure Ratio
Western Toad			
Arsenic	29.0	20	1.4
Chromium	97	110	0.88
Molybdenum	n/a	n/a	n/a
Nickel	n/a	n/a	n/a
Selenium	n/a	n/a	n/a

Note: COPC - Chemical of Potential Concern; mg/kg/d - milligrams per kilograms per day; n/a- not available / not applicable (a) Exposure estimate is based on soil exposure: TRV-Toxicological Reference Value. (b) TRV is based on BC MOE 2002, Sediment Quality Criteria for Typical Sites

The ERs for arsenic and chromium are based on screening values for benthic invertebrates and are considered conservative for the protection of amphibians. ERs were not completed for Molybdenum, Nickel, and Selenium as there are no TRVs available for these COPCs for amphibians.

6.12.5.7 Limitations

Assessing health risks from environmental chemicals is always associated with uncertainty. Where there was uncertainty, conservative assumptions have been used to ensure that risks have not been underestimated (and in fact almost certainly overestimated). In the exposure assessment, uncertainty relates to the assumptions regarding the presence of VCs. Conservative assumptions have been made to ensure any ecological receptors that may be present in the vicinity of the proposed Project site are provided with sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, which is why there is some uncertainty associated with toxicity reference values. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs). This is because most reference values are based on the most sensitive species tested or a similar low effect level (e.g., 10^{th} or 25^{th} percentile of species sensitivity distribution), and toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e., the use of soluble metal salts).

COPCs emissions data were not available for this assessment. Emissions data can be an important component of a risk assessment as it can be a key pathway for the dispersion of COPCs. Air dispersion modeling for COPCs concentrations for baseline and proposed Project effects was not completed for the ERA (Appendix 6.12-A). Long-term ambient monitoring at near-by sites has not been implemented because of lack of anthropogenic activities, the remote location and its difficult access, and likely ultra-low concentrations of CACs which are anticipated to be below the detection limit of a typical portable monitoring station. Developing background concentration by means of air dispersion modelling is also not feasible for the proposed Project because of a lack of specific emission sources. Baseline data for most exposure media pathways (i.e., soil, vegetation, berries) were used because proposed Project effects data were unavailable for the ERA. Proposed Project effects data were used when available (i.e., surface water data).

For risk characterisation, the ERs generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring. There is greater inherent uncertainty associated with results of screening level assessments than higher-tier assessments because results are primarily based on modelled or estimated concentrations and TRVs derived from literature studies, rather than direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure were made and no toxicity studies were performed.

In many cases and for a variety of reasons, toxicity at a site is considerably diminished compared to effects predicted from laboratory studies. Higher-tier assessments (i.e., Preliminary Quantitative ERA) incorporate site-specific toxicity data in a lines-of-evidence approach, which can reduce the level of uncertainty in this phase of the assessment.

6.12.5.8 Conclusion

ERs for amphibians exposed to COPCs in the surface water could not be calculated due to a lack of an appropriate TRV. Therefore, COPCs that exceed water quality guidelines for amphibians are considered uncertainties in the assessment.

Risks to amphibians exposed to COPCs in soil were characterised by comparing the exposure estimates for each COPC to TRVs for the Western toad. The ER (based on screening values for benthic invertebrates) for arsenic exceeds 1 while the ER (based on screening values for benthic invertebrates) for chromium was below 1. Risk estimates are presented in Table 6.12.5-4. Baseline soil concentrations were used to screen for COPCs as predicted soil data during operations and post closure were not available to support the effects assessment. Current assessment findings predict no residual effect of the proposed Project; however limitations in the available data limit the ability to predict the proposed Project effects on the health of amphibians.

The ERs for arsenic and chromium are based on screening values for benthic invertebrates and are considered conservative for the protection of amphibians. ERs were not completed for Molybdenum, Nickel and Selenium as there are no TRVs available for these COPCs for amphibians.

6.12.6 VC #5: Fish

6.12.6.1 Introduction

Fish have been included as a VC to address concerns that their health could be adversely affected by chemicals introduced or mobilised in the environment as a result of the proposed Project. Dolly Varden *(Salvelinus malma)* has been selected as a surrogate species and has been used in the assessment.

Dolly Varden

Dolly Varden has been assessed as a receptor because this species was identified as a VC and because of its importance in the ecosystem as a predator and as a food source for piscivorous birds and mammals. It is assumed that if risks are acceptable for Dolly Varden, then risks would be acceptable for all freshwater fish.

As Dolly Varden are primarily insectivorous, they are an important higher trophic level downstream of the proposed Project, and are considered to be important from a social aspect as well. Depending on their life history, different species of fish can be exposed to contaminants in surface water in different ways; however, the route of potential exposure for Dolly Varden is assumed to be uptake of COPCs in surface water across the gills. Exposure estimates for these fish are based on the 95^{th} percentile concentrations in surface water collected.

6.12.6.1.1 Relevant Legislation and Legal Framework

The ERA has been completed according to accepted (ERA) methodologies and guidance published by regulatory agencies including CCME (1996a, 1997), BC MOE (1998), and US EPA (1998).

6.12.6.1.2 Spatial Boundaries

Spatial boundaries for the risk assessment correspond to the spatial boundaries of other environmental disciplines as necessary. The LSA and RSA are based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range, and activities that would bring the receptor into contact with various environmental media. In any population of organisms, there was extensive variability among individuals for each of these parameters. For fish, the LSA and RSA would be similar to that of the air quality study areas. The air quality discipline (Section 6.2) defines the LSA as 2 km wide surrounding the proposed Project footprint and the RSA as 2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).

6.12.6.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project, which are contingent on permitting, include four primary phases:

1. Construction Phase – estimated 25-month period. This includes:
   - Site clearing and preparation, earthworks such as excavating and site grading;
   - Construction of mine site roads and power distribution lines on the site;
   - Facilities, such as processing plant, Tailings Management Facility (TMF) starter embankment, reclaim pipe works;
   - Camp complex; and
   - May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).
2. Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years would be spent milling low-grade ore). This includes progressive reclamation.
3. Decommissioning and Closure Phase – estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase – estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse

effects on local receiving waters. Stabilisation of the WRMF and TMF will also be considered in post-closure monitoring.

6.12.6.2 Information Sources and Methods

Environmental chemistry data have been obtained from the surface water discipline. Organisms of concern were identified based on information provided by the fisheries discipline. Analytical chemistry data for surface water have been assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- BC MOE water quality guidelines for the protection of aquatic life (BC MOE 2006a,b); and
- CCME's Canadian Environmental Quality Guidelines: "Canadian Water Quality Guidelines for the Protection of Aquatic Life" (CCME 2007).

Ecological health risks were assessed by following Ecological Risk Assessment guidance materials recommended by the BC MOE (1998), CCME (1996a, 1997), and US EPA (1998).

6.12.6.3 Baseline Description of VC #5: Fish

The Environmental Health Baseline Report (Appendix 6.12-A) summarises the baseline health risks for fish in the vicinity of the proposed Project.

The baseline prediction was completed using site soils and water quality data as a representation of site conditions prior to the project. The baseline data are to be compared to the effects assessment that used water quality data modelled for the construction, operations, and closure / decommissioning phases of the proposed Project.

Risks to fish were characterised by comparing the 95th percentile of surface water for each COPC to TRVs for the Dolly Varden. ERs for all COPCs were below 1 for fish exposures. No adverse effects have been predicted for fish (Table 6.12.6-1).

Table 6.12.6-1: Baseline Risk Estimates for Fish

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Cadmium	0.94	0.0017	0.61
Molybdenum	128.8	0.37	0.87

Note: COPC - Chemical of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference

6.12.6.4 Cultural Ecological or Community Knowledge

6.12.6.4.1 Nisga’a Nation

The Nisga’a Nation has the collectively held right to harvest fish and aquatic plants for domestic (i.e., food, ceremonial, and social) purposes subject to conservation and safety measures. The NFA defines the rights and responsibilities of the Nisga’a Nation and NLG with regard to managing, harvesting, and enhancing Nass watershed fishery resources.

The Nisga’a Nation’s salmon and steelhead allocations are based on a percentage of the annual allowable harvest (Tables 6.12.6-2and 6.12.6-3). BC and Canada do not require licenses or fees and royalties for Nisga’a fish harvest, with the exception of the use of firearms and fish sales. Nisga’a Nation citizens also have the right to barter or trade fish resources amongst themselves or with other Aboriginal groups.

Table 6.12.6-2: Summary of Nisga’a Salmon Allocations Per Species

Species	Sockeye	Pink	Chinook	Coho	Chum
Nisga’a have (%) of return to Canada	10.5%	0.6%	21.0%	8.0%	8.0%
Return to Canada: small	160,000	300,000	13,000	40,000	30,000
Return to Canada: large	600,000	1,100,000	60,000	240,000	150,000
Nisga’a fish allocations: threshold (at small return)	16,800	1,800	2,730	3,200	2,400
Nisga’a fish allocations: maximum (at large return)	63,000	6,600	12,600	19,200	12,000

Note: % - percent

Source: BC MARR 2000

The Nisga’a Nation harvest of summer- and winter-run steelhead is dependent on conservation consideration. If there are no conservation concerns that arise from the review of studies conducted for steelhead, the Nisga’a Nation have the right to harvest steelhead for domestic purposes. If conservation concerns exist, the Nisga’a Nation has the right harvest steelhead according to Schedule D of Chapter 8 of the NFA up to a maximum harvest of 1,000 steelhead per year (Table 6.12.6-3).

Table 6.12.6-3: Summary of Annual Nisga’a Steelhead Allocation

	Percentages
Adjusted total allowable catch	95% of return to Canada – annual escapement goal
Nisga’a allocation	5% of total returns
	25% of adjusted allowable catch
Maximum	1,000 steelhead

Note: % - percent

Source: BC MARR 2000

6.12.6.4.2 Aboriginal Groups

All of the five potentially affected Aboriginal groups have interests in fish and fishing. Fishing for sockeye, pink, Coho, chum, and Chinook salmon, steelhead, rainbow trout, Dolly Varden, and cutthroat trout is important for Kitselas subsistence, economic, and cultural purposes. Salmon have long been, and continue to be, a dietary staple for the Kitselas First Nation, who use the Skeena River and its tributaries for fishing. Sockeye and spring salmon are the preferred fish species by the Kitselas as an important source of food. Fishing occurs during spring and fall runs, and some fishing, such as for steelhead, may occasionally occur during the winter. The Kitselas's economic ventures include a commercial and scientific fisheries operation and a federally funded Selective Fisheries Program.

The location of *Dalk Gyilkyaw* (Robin Town at the Kitsumkalum canyon) was ideal for fishing and trapping, and for using dipnets to catch salmon and other fish. The village of *Kitsumkalum* was also established on an abundant fishing location. The Kitsumkalum participated in the oolichan fishery on the Nass River, and were given the right to make grease from the base of Red Cliffs.

From mid-February to April, Metlakatla used camps and facilities at the mouth of the Nass River to fish for oolichan. Oolichan grease was a particularly important commodity for the Tsimshian. In May, activity shifted to the camps where seaweed was gathered and dried, while men typically fished for halibut, and herring spawn. The Metlakatla were traditionally highly reliant on fish and marine resources. They used marine and freshwater aquatic resources for food, social, ceremonial, and commercial purposes, and created surplus to use in times of shortage or for trade.

Sockeye salmon is the fish species of greatest importance to the Gitanyow *wilp*. In the past, Gitanyow fishing sites were located on the Kitwanga and Cranberry river systems; however, given the depleted sockeye salmon stocks on the Kitwanga River, Gitanyow have moved their fisheries to the Meziadin-Nass river system. Members of *wilp* Watakhayetsxw also fish for Coho and pink salmon in the canyon of the Cranberry River, which proximate to Kitsault transportation route. The Gitanyow indicate that the Cranberry has important spawning and rearing habitat. Salmon habitat is especially important to Gitanyow, because they rely on salmon and other fish species for sustenance and culture purposes.

Gitxsan fished for salmon, steelhead and other fish species, and hunted beaver in early spring. In summer and fall, the Gitxsan fished for salmon. Gitxsan also participated in ice-fishing activities, primarily for steelhead. Co-management is shared with the Fisheries and Oceans Canada (DFO) and BC Ministry of Forests, Range and Natural Resource Operations (BC MFLNRO), which co-operate with the Gitxsan Watershed Authorities in managing fish stocks, wildlife, and species at risk.

6.12.6.5 Past, Present, or Future Projects / Activities That May Interact With VC #5

The current assessment evaluates future ecological health risks potentially associated with the proposed Project, relative to baseline conditions that, by definition, would include any past or present projects in the vicinity. The following will be considered for the assessment:

- **Historical land use,** including previous mining and exploration activities and construction of the Kitsault Townsite, which is located 5 km from the proposed Project;
- **Current land use,** including nearby transportation and access roads, ongoing mining exploration, trapping and guide outfitting, marine boat traffic, and recreational fishing; and
- **Future land use,** including the NTL Project.

6.12.6.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to environmental health since they could adversely affect the long-term health of fish. Emphasis is placed on identifying metals as COPCs, since metals usually pose the most potential for adverse health risks at mines. Mining projects often have high metal concentrations and volumes in mining wastes and dust generated from mining activities. High metal concentrations often persist in the environment. The environmental health component provides information, including chemical analyses and modelling results, and data through exposure modelling calculations to assess potential effects on the health of fish.

6.12.6.6.1 Identification and Analysis of Potential Project Effects

Ecological COPCs have been identified by screening the 95th percentile concentrations for surface water against CCME guidelines (or other toxicity-based guidelines as appropriate) and local background concentrations. Chemicals were assessed in the ERA if the 95th percentile concentration exceeded the relevant guideline, or the detection limit exceeded the guideline. The results of the COPC screening are summarised in Table 6.12.6-4.

Table 6.12.6-4: Screening of Chemicals of Potential Concern in Surface Water for Fish

Metal COPC	Screening Guideline for Surface Water	
	95th Percentile Concentrations for Surface Water (mg/L) (a)	Freshwater Aquatic Life Health
Antimony	0.02	0.02 (c)
Arsenic	0.013	0.005 (b)
Barium	0.056	5 (c)
Beryllium	0.0007	0.0053 (d)
Cadmium	0.0029	0.00017 (b)
Chromium	0.0015	0.001 (c)
Cobalt	0.00034	0.11 (c)

Copper	0.012	0.002 (b)
Lead	0.011	0.001 (b)
Mercury	0.00019	0.000026 (b)
Molybdenum	1.6	0.073 (b)
Nickel	0.028	0.025 (b)
Selenium	0.015	0.002 (b)
Silver	0.00006	0.0015 (b)
Thallium	0.00011	0.0003 (d)
Vanadium	0.003	0.006 (d)
Zinc	0.065	0.033 (b)

Note: COPC - Chemical of Potential Concern; mg/L - milligrams per litre; (a) 95th percentile of project effects surface water concentrations (all project phases). Concentrations provided by AMEC Water / Sediment Quality Group. (b) CCME Canadian Environmental Quality Guidelines: “Canadian Water Quality Guideline for the Protection of Aquatic Life” (CCME 2007). (c) BC Water Quality Guideline (maximum) for the Protection of Freshwater Aquatic Life (Government of BC 2010). (d) BC Water Quality Guideline (30-day average) for the Protection of Freshwater Aquatic Life (Government of BC 2010). Highlighted cell indicates metal is a COPC in specified medium for ecological risk assessment. Metal was selected as a COPC in water if the 95th percentile concentration exceeded screening guideline in water.

Screening for Surface Water

The reported concentration data for surface water have been assessed and evaluated for the purposes of identifying COPCs using:

- CCME’s Canadian Environmental Quality Guidelines: “Canadian Water Quality Guidelines for the Protection of Aquatic Life” (CCME 2011).

Summary of Identified COPCs

Based on the screening conducted for surface water concentrations (Table 6.12.3-2), the following compounds were identified as COPCs in surface water for fish and were carried forward in the ERA for the proposed Project:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Lead;
- Mercury;
- Molybdenum;
- Nickel;
- Selenium; and

- Zinc.

The remaining COPCs found in surface water were below their respective guidelines for fish and have not been carried forward in the assessment.

Exposure Assessment

The exposure assessment includes an analysis of the pathways through which VCs may be exposed to COPCs and an estimate of the concentrations to which they may be exposed. For COPCs to have deleterious effects on ecological receptors, the COPC must have contact with the organism or receptor. The route by which this occurs is referred to as an exposure pathway and is dependent on the nature of the chemical and the nature of the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of COPCs must be present;
- Release and transport mechanisms and media must be available to move the COPC from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the COPC is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

Pathway Analysis

Direct Exposure to COPCs in Surface Water

Metals in surface water can exist in several forms, most commonly in dissolved forms or absorbed to suspended particulates. Metals dissolved in surface water readily bind to respiratory surfaces and induce adverse effects in fish. It is generally accepted that toxicological effects are most closely associated with the dissolved fraction of metals, and most toxicological models assume metals must be in solution to induce toxicity. Nevertheless, in practical terms this has little bearing on the evaluation of exposure in a screening-level ERA, as aqueous toxicological data is, in almost all cases, simply related to total metal concentration (i.e., dissolved and suspended solids).

Exposure Estimates

The 95^{th} percentile concentrations in the surface water media used for fish are presented in Table 6.12.6-5.

Table 6.12.6-5: Ecological Risk 95^{th} Percentile Concentrations for Surface Water

Metal COPC	95th Percentile Surface Water Concentration (mg/L)
Arsenic	0.0129
Cadmium	0.0029

Metal COPC	95th Percentile Surface Water Concentration (mg/L)
Chromium	0.0015
Copper	0.012
Lead	0.011
Mercury	0.00019
Molybdenum	1.61
Nickel	0.0282
Selenium	0.016
Zinc	0.065

Note: COPC - Chemical of Potential Concern; mg/L - milligrams per litre

Toxicity Assessment

For fish, TRVs representing concentrations of COPCs in surface water that would not result in adverse health effects were presented in Table 6.12.6-6.

Table 6.12.6-6: Toxicological Reference Values for Fish

Metal COPC	TRV (mg/L)	Reference
Arsenic	0.892	Sample et al. (1996). Based on early life stage test.
Cadmium	0.0017	Sample et al. (1996). Lowest chronic value.
Chromium	0.073	Sample et al. (1996). Based on early life stage test on rainbow trout.
Copper	0.0038	Sample et al. (1996). Based on early life stage test on brook trout.
Lead	0.0188	Sample et al. (1996). Based on early life stage test on rainbow trout.
Mercury	0.023	Sample et al. (1996). Lowest Chronic Value
Molybdenum	0.370	Sample et al. (1996). Secondary Chronic Value
Nickel	0.035	Sample et al. (1996). Based on early life stage test on rainbow trout.
Selenium	0.0883	Sample et al. (1996). Lowest Chronic Value
Zinc	0.036	Sample et al. (1996). Lowest Chronic Value

Note: COPC - Chemical of Potential Concern; TRV - Toxicological Reference Value; mg/L - milligrams per litre

Risk Characterisation

ERs are a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure Ratio} = \frac{\text{Exposure Estimate}}{\text{TRV}}$$

ERs are interpreted as follows:

If the ER is less than 1, no unacceptable risks to fish would be expected, because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds 1, it may be inferred that adverse effects to individuals are possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV that was based on a 25% reduction in a growth-based endpoint (ER>1), it can be inferred that one possible outcome may be diminished growth of individuals in a population. This can potentially (but not necessarily) lead to a reduction in population abundance of that receptor. It is important to note that exceeding an ER of one does not necessarily mean that adverse effects will definitively occur; rather, it suggests that there is a lower confidence that adverse effects will not occur. It is also important to recognise that the magnitude of ERs is not directly associated with the magnitude of potential effects. That is, a large ER (>10) should not be interpreted as a 10-fold greater risk than an ER of 1.

For those COPCs with ERs greater than 1, potential risks at a population level cannot be ruled out and should be evaluated further. Evidence from sources other than chemical analysis may be employed, including toxicity of media in laboratory exposures (i.e., bioassays), the absence of species formerly present or commonly found at similar sites, or diminished populations compared to a reference location.

Quantitative Interpretation of Risk Hazard

Risks to fish exposed to COPCs in surface water were characterised by comparing exposure estimates for each COPC to TRVs for the Dolly Varden. ERs for cadmium, copper, and molybdenum exceeded 1 for Dolly Varden while ERs for the remaining COPCs were below 1. Risk estimates for fish are presented in Table 6.12.6-7.

Table 6.12.6-7: Risk Estimates for Fish

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Dolly Varden			
Arsenic	0.0129	0.892	0.014
Cadmium	0.0029	0.0017	1.7
Chromium	0.0015	0.073	0.02
Copper	0.012	0.0038	3.1
Lead	0.011	0.0188	0.57
Mercury	0.00019	0.023	0.008
Molybdenum	1.61	0.370	4.4
Nickel	0.0282	0.035	0.81

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Selenium	0.016	0.0883	0.18
Zinc	0.065	0.036	0.61

Note: COPCs - Chemicals of Potential Concern; mg/kg/d - milligram per kilogram per day; TRV - Toxicological Reference Value

6.12.6.7 Limitations

Assessing health risks from environmental chemicals is always associated with uncertainty. Where there is uncertainty, conservative assumptions have been used to ensure that risks are not underestimated (and in fact almost certainly overestimated). In the exposure assessment, uncertainty relate to the assumptions regarding the presence of VCs. Conservative assumptions have been made to ensure any ecological receptors that might be present in the vicinity of the proposed Project site are provided sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, there is some uncertainty associated with TRVs. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs). This is because most reference values are based on the most sensitive species tested or a similar low effect level (e.g., 10th or 25th percentile of species sensitivity distribution), and toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e., the use of soluble metal salts).

For risk characterisation, the ERs generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring. There is greater inherent uncertainty associated with results of screening level assessments than higher-tier assessments, because results are based primarily on modelled or estimated concentrations and TRVs derived from literature studies, rather than direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure were made and no toxicity studies were performed. In many cases, toxicity at a site is considerably diminished compared to effects predicted from laboratory studies, for a variety of reasons. Higher-tier assessments (i.e., Preliminary Quantitative ERA) incorporate site-specific toxicity data in a lines-of-evidence approach, which can reduce the level of uncertainty in this phase of the assessment.

6.12.6.8 Conclusion

Quantitative estimates of risk have been calculated using a quotient approach in which exposure estimates based on 95th percentile concentrations have been compared to TRVs derived for each receptor / pathway. ERs greater than 1 were found for Dolly Varden exposed to cadmium, copper, and molybdenum via direct contact with surface water while ERs for all remaining COPCs were below 1 (Table 6.12.6-5).

Risk estimates for the proposed Project differ from the baseline. For fish, ERs for certain COPCs are higher in the effects assessment when compared to the baseline. Proposed Project effects surface water data (construction, operations, closure, and post-closure) used in the ERA may have contributed in the change in ERs from baseline assessment to effects assessment.

6.12.7 VC #6: Soil Invertebrates

6.12.7.1 Introduction

Soil invertebrates have been selected as a VC to address concerns that their health could be adversely affected by chemicals introduced or mobilised in the environment as a result of proposed Project activities.

Soil Invertebrates

Open areas or areas with barren earth likely support indigenous soil invertebrates such as earthworms, grubs, arthropods, etc. In terms of sensitivity to toxicants, earthworms are considered to be one of the most sensitive receptors for soil contaminants. Earthworms are in near-constant direct dermal contact with soil, and are probably the most important soil invertebrate in promoting soil fertility (Edwards 1992). Their feeding and burrowing activities break down organic matter and release nutrients and improve aeration, drainage, and aggregation of soil. Earthworms are also important components of the diets of many higher animals. Due to their importance in a healthy ecosystem, as well as their ubiquity in the environment, earthworms have been selected as a representative surrogate for all soil invertebrate species.

6.12.7.1.1 Relevant Legislation and Legal Framework

The ERA has been completed according to accepted (ERA) methodologies and guidance published by regulatory agencies including CCME (1996a, 1997), BC MOE (1998), and US EPA (1998).

6.12.7.1.2 Spatial Boundaries

Spatial boundaries for the risk assessment correspond to the spatial boundaries of other environmental disciplines as necessary. The LSA and RSA are based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range, and activities that would bring the receptor into contact with various environmental media. In any population of organisms, there is extensive variability among individuals for each of these parameters. For soil invertebrates, the LSA and RSA would be similar to that of the air quality study areas. The air quality discipline (Section 6.2) defines the LSA as 2 km wide surrounding the proposed Project footprint and the RSA as 2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).

6.12.7.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project, which are contingent on permitting, include four primary phases:

1. Construction Phase – estimated 25-month period. This includes:
   - Site clearing and preparation, earthworks such as excavating and site grading;
   - Construction of mine site roads and power distribution lines on the site;
   - Facilities, such as processing plant, Tailings Management Facility (TMF) starter embankment, reclaim pipe works;
   - Camp complex; and
   - May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).
2. Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years would be spent milling low-grade ore). This includes progressive reclamation.
3. Decommissioning and Closure Phase – estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase – estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse effects on local receiving waters. Stabilisation of the WRMF and TMF will also be considered in post-closure monitoring.

6.12.7.2 Information Source and Methods

Environmental chemistry data was obtained from the soil discipline and compared to the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2007), for residential / parkland land use.

Ecological health risks were assessed by following Ecological Risk Assessment guidance materials recommended by the BC MOE (1998), CCME (1996a, 1997), and US EPA (1998).

In order to evaluate the overall exposure of the human or ecological receptors to project-related emissions, mathematical models were used to predict changes in the COPC concentration in the different media from baseline conditions. The chemical composition of the surface waters in rivers and creeks forming the watershed in the vicinity of the proposed mine site can mainly be altered as a result of the surface run-off of chemicals from the site through drainage ditches or from the process-water outfall into any given water body. Chemicals in the surface water can be found in either the dissolved or suspended solid state. Atmospheric depositions can also add to the increase in COPC concentration in water bodies but its overall contribution is much smaller than direct intake from discharge lines or site run-off.

The situation is different for soil and vegetation. Atmospheric depositions (wet and dry) from project emissions are the only source of COPCs that can modify the soil chemical composition. Vegetation is affected by airborne emissions both through direct deposition and indirectly via uptake of deposited chemicals from the soil. For the Kitsault mine project, fugitive dust deposition modeling states that dust deposition along the haul road would be approximately 2.1 g/m^2/month five meters from the road, decreasing to 0.004 g/m^2/month within the LSA. These dust fall estimates are well below BC MOE objective of 8.7 g/m^2/month. Therefore, based on minimal atmospheric deposition, it is not expected that COPCs concentration in soil and vegetation surrounding the proposed mine site will be affected during the project phase.

6.12.7.3 Baseline Description of VC #6: Soil Invertebrates

The Environmental Health Baseline Report (Appendix 6.12-A) summarises the baseline risks to the health of soil invertebrates for the proposed Project. Soil invertebrates were assessed as receptors in the baseline study.

The baseline prediction was completed using site soils and water quality data as a representation of site conditions prior to the onset of the proposed Project. The baseline data are intended to be compared to the effects assessment that relies on water quality data modelled for the construction, operations, and closure / decommissioning phases of the proposed Project.

Risks to soil invertebrates exposed to COPCs in soil have been characterised by comparing 95th percentile concentrations of COPCs in soil to TRVs for the soil invertebrates. The ER for arsenic, chromium, and molybdenum exceeded 1, but the ER for the remaining COPCs were below 1 (Table 6.12.7-1).

Table 6.12.7-1: Baseline Risk Estimates for Soil Invertebrates

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Arsenic	29.0	17	1.7
Chromium	97.0	64	1.5
Molybdenum	94.9	10	9.5
Nickel	99.4	280	0.36
Selenium	1.4	4.1	0.34

Note: COPC - Chemicals of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

6.12.7.4 Cultural Ecological or Community Knowledge

6.12.7.4.1 Nisga'a Nation

The NFA defines Nisga'a rights to harvest wildlife, which includes invertebrates. There is no other reference in the NFA regarding invertebrates. Desk-based research and engagement activities with NLG did not indicate any specific concern or issue with soil invertebrates. Ongoing consultation with NLG may provide additional information and insight into the value and interests of the health of soil invertebrates (if any) related to proposed Project.

6.12.7.4.2 Aboriginal Groups

Desk-based research and engagement activities with potentially affected Aboriginal groups did not indicate any specific concern or issue with soil invertebrates. Ongoing consultation with Aboriginal groups may provide additional information and insight into the value and interests of the health of soil invertebrates (if any) related to proposed Project.

6.12.7.5 Past, Present, or Future Projects / Activities That May Interact With VC #6

The current assessment evaluates future ecological health risks potentially associated with the proposed Project, relative to baseline conditions that, by definition, would include any past or present projects in the vicinity. The following will be considered for the assessment:

- **Historical land use,** including previous mining and exploration activities and construction of the Kitsault Towsite, which is located 5 km from the proposed Project;
- **Current land use,** including nearby transportation and access roads, ongoing mining exploration, trapping and guide outfitting, marine boat traffic, and recreational fishing; and
- **Future land use,** including the NTL Project.

6.12.7.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to environmental health since they could adversely affect the long-term health of soil invertebrates. Emphasis is placed on identifying metals as COPCs, since metals usually pose the most potential for adverse health risks at mines. Mining projects often have high metal concentrations and volumes in mining wastes and dust generated from mining activities. High metal concentrations often persist in the environment. The environmental health component provides information, including chemical analyses and modelling results, and data through exposure modelling calculations to assess effects on the health of soil invertebrates.

6.12.7.6.1 Identification and Analysis of Potential Project Effects

Ecological COPCs were identified by screening the 95th percentile concentrations for soil against CCME guidelines (or other toxicity-based guidelines as appropriate) and local background concentrations. Baseline soil concentrations have been used to screen for soil because proposed Project effects data were not available for the assessment. Chemicals were assessed in the ERA if the 95th percentile concentration exceeded the relevant guideline, or the detection limit exceeded the guideline.

For the purpose of the ERA, the proposed Project is considered to be "residential / parkland." The site was considered to represent residential / parkland land use because: (1) it is an environment dominated primarily by open woodland areas and barren areas; and (2) it is expected to provide habitat for ecological receptors. The results of the COPC screening are summarised in Table 6.12.7-2.

Table 6.12.7-2: Screening of Chemicals of Potential Concern in Soil

Metal COPC	Soil Milligrams per Kilogram (mg/kg)		
	95th Percentile of Baseline Soil Concentrations (a)	Screening Guideline	
		CCME (b)	Government of BC (c)
Aluminum	44275	n/a	n/a
Antimony	5.0	20	20
Arsenic	29.0	17	n/a
Barium	175.5	500	n/a
Beryllium	0.84	4	4
Cadmium	0.97	10	n/a
Chromium	97.0	64	n/a
Cobalt	26.2	50	50
Copper	49.2	63	n/a
Lead	48.0	140	n/a
Manganese	3272	n/a	n/a

Metal COPC	Soil Milligrams per Kilogram (mg/kg)		
	95th Percentile of Baseline Soil Concentrations (a)	Screening Guideline	
		CCME (b)	Government of BC (c)
Mercury	0.25	6.6	n/a
Molybdenum	94.9	10	10
Nickel	99.4	50	100
Selenium	1.4	1	3
Silver	7.2	20	20
Strontium	36.1	n/a	n/a
Thallium	0.5	1	n/a
Tin	7.7	n/a	50
Vanadium	98.1	130	200
Zinc	163.5	200	n/a

Note: BC - British Columbia; CCME - Canadian Council of Ministers of the Environment; COPC - Chemical of Potential Concern; mg/kg - milligrams per kilogram; n/a - not applicable (a) 95th percentile of baseline soil concentrations. Concentrations provided by Rescan and AMEC Soil Quality Group. (b) Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guideline for the protection of Environmental Health" (CCME 2007). Value represents guideline protective of residential / parkland uses. (c) BC *Environmental Management Act*, *Contaminated Sites Regulation*, Schedule 4 Numeric Soil Standards. Highlighted cell indicates metal is a COPC in specified medium. Metal was selected as a COPC: in soil if the 95th percentile of the concentration exceeded screening guideline for soil.

Screening for Soil

Analytical chemistry data for soil were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- BC *CSR* of the BC *EMA*, Schedule 4 Generic Numerical Soil Standards, for park and residential use; and
- Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2011), assuming a residential / parkland land use.

Based on the screening conducted for soil concentrations, the following chemicals were identified as COPCs in soil and were carried forward in the ERA for the proposed Project:

- Arsenic;
- Chromium;
- Molybdenum;
- Nickel; and

- Selenium.

The remaining COPCs found in soil were below their respective guidelines and were not carried forward in the assessment.

Exposure Assessment

The exposure assessment includes an analysis of the pathways through which VCs may be exposed to COPCs and an estimate of the concentrations to which they may be exposed. For COPCs to have deleterious effects on ecological receptors, the COPC must have contact with the organism or receptor. The route by which this occurs is referred to as an exposure pathway and is dependent on the nature of the chemical and the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of COPCs must be present;
- Release and transport mechanisms and media must be available to move the COPC from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the COPC is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

Pathway Analysis

The primary route of exposure for soil invertebrates is direct contact with, or ingestion of, COPCs in soil. Earthworms are known to take up various inorganic and organic soil contaminants through consumption of humus (well-decomposed organic material) in surface soil and less decomposed leaf litter at the ground surface. The uptake of metals into the tissue of earthworms primarily depends on the metal's physicochemical properties. Site-specific factors such as organic content of the soil can also affect availability.

The feeding and burrowing habits of earthworms determine their exposure to chemicals in soil and litter. Earthworms may be categorised into three groups based on feeding habits and the structure of burrows:

- Litter-feeding species forage on surface litter, but build deep, vertical burrows up to 3 metres (m) below the surface;
- Geophagus species consume large amounts of soil during feeding on humus in near-surface strata, and construct primarily shallow, horizontal burrows; and
- Worms resting during cold or dry conditions construct ephemeral vertical burrows in upper soil strata.

Depending on the depth of contamination, geophagus organisms and those living on or near the soil surface may have very different exposure to chemicals than worms feeding on litter pulled down into burrows in the subsoil (Curl et al. 1987). For a situation such as one that exists at the proposed Project site, burrowing depth is the dominant factor affecting exposure. Lee (1985) reviewed studies of earthworm burrow morphology for several species in various countries. Although a few species not present in Canada (e.g., *Microchaetus microchaetus*, *Octochaetus multiporus*) are known to burrow to depths as great as 3 m below the surface, more common species of *Lumbricus* and *Eisenia* generally burrow only in the upper 0.8 m, or even the upper 0.1 m (Lee 1985). Zicsi (1983) identified several European species that burrow up to 1.5 m (Suter et al. 2000). Other studies have demonstrated that even among species known to be capable of creating deep casts, the largest fraction of biomass is frequently found in the upper soil strata where concentrations of organic materials are greatest (Suter et al. 2000). For example, densities of *Aporrectodea caliginosa*, which burrows to depths up to 0.3 m or more, were greatest from 0 to 8 centimetre (cm) depth, intermediate in layers 8 to 15 cm and 15 to 20 cm, and lowest from 20 to 30 cm (Pitkanen and Nuutinen 1997).

Given the distribution of metals in soil at the site, exposure of earthworms to COPCs via direct contact with contaminated soil was assumed to be a complete exposure pathway in the ERA.

Exposure Estimates

Because soil invertebrates do not move over large distances so exposure to contaminants cannot be averaged or integrated among areas of a site with higher and lower concentrations. Some fraction of individuals in a population at a site are potentially exposed to the highest concentrations of COPCs. Therefore, exposure estimates are based on upper estimates of concentrations at the proposed Project site. Although the maximum measured concentration can be used as a very conservative estimate of exposure, use of the maximum would ensure protection of 100% of individuals, which is not consistent with the objectives of the assessment or standard practice in the ERA. Instead, the 95th percentile of the distribution of COPC concentrations is used as an estimate of exposure (Table 6.12.7-3). Use of the 95th percentile describes the use of a concentration that is 95% of the maximum concentration sampled or modelled.

Table 6.12.7-3: Ecological Risk 95th Percentile Concentrations for Soil

Metal COPC	95th Percentile Soil Concentrations (mg/kg)
Arsenic	29.0
Chromium	97.0
Molybdenum	95.0
Nickel	99.5
Selenium	1.14

Note: COPC - Chemical of Potential Concern; mg/kg - milligrams per kilogram

Toxicity Assessment

For soil invertebrates, TRVs representing concentrations of COPCs in soil that would not result in adverse health effects have been identified:

Arsenic

Vaughan and Greenslade (1998) investigated the effects of arsenic on earthworms (*Eisenia andrei*) growing in an artificial soil for 14 days. The Lethal Concentration Effective to Reduce in 50% Mortality (LC_{50}) of 472 parts per million (ppm) was derived from the study. In the same study, a 28-day reproduction investigation was completed with adult springtails (*Folsomia candida*). A No Observable Effect Concentration (NOEC) of 10 ppm and an EC_{50} of 119 ppm was estimated from the study.

The CCME's SQG_E of 17 mg/kg for residential / parkland use was adopted as the TRV for soil invertebrates (CCME 1997b). This guideline is intended to protect plants and other terrestrial biota from direct soil contact at a level consistent with the purposes of a residential / parkland land use.

Chromium

The CCME's SQG_E of 64 mg/kg for residential / parkland property use was adopted as the TRV for soil invertebrates (CCME 1997b). This guideline is intended to protect plants and other terrestrial biota from direct soil contact at a level consistent with the purposes of a residential / parkland land use.

Molybdenum

The CCME's interim Soil Quality Guideline for the health of the Environment (SQG_E) of 10 mg/kg for residential / parkland use was adopted as the TRV for soil invertebrates (CCME, 1997b). This guideline is intended to protect plants and other terrestrial biota from direct soil contact at a level consistent with the purposes of a residential / parkland land use.

Nickel

Scott-Fordsmand et al. (1999) investigated the effects of nickel on springtail (*Folsomia fimetaria L.*) growing in an artificial soil. A geometric mean of NOAEC and LOAEC value of 387 mg/kg was derived from the study. The Eco-SSL value for nickel for soil invertebrates is 280 mg/kg (US EPA 2005). The value was adopted as the TRV for soil invertebrates. This guideline is intended to protect soil invertebrates.

Selenium

Checkai et al. (2004) investigated the effects of selenium on the earthworm growing in an artificial soil. An EC_{20} (effective concentration to induce a 20% effect) value of 3.4 mg/kg was derived from the study. The Eco-SSL value for selenium for soil invertebrates is 4.1 mg/kg (US EPA 2005) and this value was adopted as the TRV for soil invertebrates. This guideline is intended to protect soil invertebrates.

Risk Characterisation

ERs are a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure Ratio} = \frac{\text{Exposure Estimate}}{\text{TRV}}$$

ERs are interpreted as follows:

If the ER is less than 1, no unacceptable risks to soil invertebrates would be expected, because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds 1, it may be inferred that adverse effects to individuals are possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV that was based on a 25% reduction in a growth-based endpoint (ER>1), it can be inferred that one possible outcome may be diminished growth of individuals in a population. This can potentially (but not necessarily) lead to a reduction in population abundance of that receptor. It is important to note that exceeding an ER of one does not necessarily mean that adverse effects will definitively occur; rather, it suggests that there is a lower confidence that adverse effects will not occur. It is also important to recognise that the magnitude of ERs is not directly associated with the magnitude of potential effects. That is, a large ER (>10) should not be interpreted as a 10-fold greater risk than an ER of 1.

For those COPCs with ERs greater than 1, potential risks at a population level cannot be ruled out and should be evaluated further. Evidence from sources other than chemical analysis may be employed, including evidence of toxicity at the proposed Project site, toxicity of media in laboratory exposures (i.e., bioassays), the absence of species formerly present or commonly found at similar sites, or diminished populations compared to a reference location.

Quantitative Interpretation of Risk Hazard

Risks to soil invertebrates exposed to COPCs in soil have been characterised by comparing 95^{th} percentile concentrations of COPCs in soil to TRVs for the soil invertebrates. The proposed Project effects on soil invertebrates are not expected to change from baseline risks since the COPC soil concentrations are not expected to change. Baseline soil concentrations have been collected, and have been used as the basis for the PQRA and the assessment completed presented in this section. The baseline is representative of the existing brownfield conditions and has been considered representative of soil conditions and COPCs concentrations at the time of proposed Project closure. As a result, the risk estimates for soil invertebrates is the same for conditions if the proposed Project were to occur as those from "baseline" conditions. The ER for arsenic, chromium, and molybdenum exceed 1, but the ER for the remaining COPCs are below 1 (Table 6.12.7-4).

Table 6.12.7-4: Risk Estimates for Soil Invertebrates

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Arsenic	29.0	17	1.7
Chromium	97.0	64	1.5
Molybdenum	94.9	10	9.5
Nickel	99.4	280	0.36
Selenium	1.4	4.1	0.34

Note: COPC - Chemical of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

Based on ERs, levels of arsenic, chromium, and molybdenum in soil may pose a risk and affect soil invertebrates at the proposed Project site. However, these ERs reflect current conditions within the proposed Project site and major and widespread adverse effects to invertebrate populations are considered unlikely.

6.12.7.7 Limitations

Assessing health risks from environmental chemicals is always associated with uncertainty. Where there was uncertainty, conservative assumptions have been used to ensure that risks are not underestimated (and in fact almost certainly overestimated). In the exposure assessment, uncertainty relate to the assumptions regarding the presence of VCs. Conservative assumptions have been made to ensure any ecological receptors that might be present in the vicinity of the proposed Project site are provided sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, which is why there is some uncertainty associated with TRVs. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs). This is because most reference values are based on the most sensitive species tested or a similar low effect level (e.g., 10^{th} or 25^{th} percentile of species sensitivity distribution), and toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e. the use of soluble metal salts).

For risk characterisation, the ERs generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring. There is greater inherent uncertainty associated with results of screening level assessments than higher-tier assessments, because results are based primarily on modelled or estimated concentrations and TRVs derived from literature studies, rather than direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure were made and no toxicity studies were performed. In many cases, toxicity at a site is considerably diminished compared to effects predicted from laboratory studies, for a variety of reasons. Higher-tier assessments (i.e., Preliminary Quantitative ERA) incorporate site-specific toxicity data in a lines-of-evidence approach, which can reduce the level of uncertainty in this phase of the assessment.

6.12.7.8 Conclusion

Quantitative estimates of risk were calculated using a quotient approach in which exposure estimates based on 95th percentile concentrations were compared to TRVs derived for each receptor / pathway. ERs greater than 1 were found for soil invertebrates exposed to arsenic, chromium, and molybdenum via direct contact with soil, while ERs for all remaining COPCs for were below 1 (Table 6.12.7-4).

Risk estimates for the proposed Project are the same and do not differ from the baseline. Baseline data were used in the assessment because proposed Project effects data for soil was unavailable. Therefore, the risks in this ERA for soil invertebrates are representative of conservatively estimated baseline conditions and not conditions based on proposed Project effects.

6.12.8 VC #7: Terrestrial Plants

6.12.8.1 Introduction

Terrestrial plants have been selected as a VC to address concerns that their health could be adversely affected by chemicals introduced or mobilised in the environment as a result of the proposed Project activities.

Terrestrial Plants

Terrestrial plants have been assessed as receptors to ensure that their health and fecundity in the vicinity of the proposed Project would not be adversely affected by accumulating COPCs from soil. Certain plants in the vicinity of the proposed Project represent important country foods for local Aboriginal community populations. As autotrophs, plants are the foundation of any terrestrial ecosystem, including those heavily influenced by humans. The type and quality of vegetative growth is the most visible indicator of forest health.

6.12.8.1.1 Relevant Legislation and Legal Framework

The ERA has been completed according to accepted (ERA) methodologies and guidance published by regulatory agencies including CCME (1996a, 1997), BC MOE (1998), and US EPA (1998).

6.12.8.1.2 Spatial Boundaries

Spatial boundaries for the risk assessment correspond to the spatial boundaries of other environmental disciplines as necessary. The LSA and RSA are based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range, and activities that would bring the receptor into contact with various environmental media. In any population of organisms, there is extensive variability among individuals for each of these parameters. For terrestrial plant receptors, the LSA and RSA would be similar to that of the air quality study areas. The air quality discipline (Section 6.2) defines the LSA as 2 km wide surrounding the proposed Project footprint and the RSA as 2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).

6.12.8.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project, which are contingent on permitting, include four primary phases:

1. Construction Phase – estimated 25-month period. This includes:
   - Site clearing and preparation, earthworks such as excavating and site grading;
   - Construction of mine site roads and power distribution lines on the site;
   - Facilities, such as processing plant, Tailings Management Facility (TMF) starter embankment, reclaim pipe works;
   - Camp complex; and
   - May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).
2. Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years would be spent milling low-grade ore). This includes progressive reclamation.
3. Decommissioning and Closure Phase – estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase – estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse effects on local receiving waters. Stabilisation of the WRMF and TMF will also be considered in post-closure monitoring.

6.12.8.2 Information Source and Methods

Environmental chemistry data was obtained from the soil discipline and compared to the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2007), for residential / parkland land use.

Ecological health risks were assessed by following Ecological Risk Assessment guidance materials recommended by the BC MOE (1998), CCME (1996a, 1997), and US EPA (1998).

In order to evaluate the overall exposure of the human or ecological receptors to project-related emissions, mathematical models were used to predict changes in the COPC concentration in the different media from baseline conditions. The chemical composition of the surface waters in rivers and creeks forming the watershed in the vicinity of the proposed mine site can mainly be altered as a result of the surface run-off of chemicals from the site through drainage ditches or from the process-water outfall into any given water body. Chemicals in the surface water can be found in either the dissolved or suspended solid state. Atmospheric depositions can also add to the increase in COPC concentration in water bodies but its overall contribution is much smaller than direct intake from discharge lines or site run-off.

The situation is different for soil and vegetation. Atmospheric depositions (wet and dry) from project emissions are the only source of COPCs that can modify the soil chemical composition. Vegetation is affected by airborne emissions both through direct deposition and indirectly via uptake of deposited chemicals from the soil. For the Kitsault mine project, fugitive dust deposition modeling states that dust deposition along the haul road would be approximately 2.1 g/m^2/month five meters from the road, decreasing to 0.004 g/m^2/month within the LSA. These dust fall estimates are well below BC MOE objective of 8.7 g/m^2/month. Therefore, based on minimal atmospheric deposition, it is not expected that COPCs concentration in soil and vegetation surrounding the proposed mine site will be affected during the project phase.

6.12.8.3 Baseline Description of VC #7: Terrestrial Plants

The Environmental Health Baseline Report (Appendix 6.12-A) summarises the baseline risks to the health of terrestrial plants for the proposed Project.

The baseline prediction was completed using site soils and water quality data as a representation of site conditions prior to the onset of the proposed Project. The baseline data are to be compared to the effects assessment that used water quality data modelled for the construction ,operations, and closure / decommissioning of the proposed Project.

Risks to terrestrial plants exposed to COPCs in soil have been characterised by comparing 95th percentile concentrations of COPCs in soil to TRVs for the terrestrial plants. The ERs are greater than 1 for all COPCs in soil (Table 6.12.8-1).

Table 6.12.8-1: Baseline Risk Estimates for Terrestrial Plants

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Arsenic	29.0	17	1.7
Chromium	97.0	1	97

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Molybdenum	94.9	2	47
Nickel	99.4	30	3.3
Selenium	1.4	1	1.4

Note: COPC - Chemicals of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

6.12.8.4 Cultural Ecological or Community Knowledge

6.12.8.4.1 Nisga'a Nation

The NFA defines rights and responsibilities of the Nisga'a Nation in terms of timber and Non-Timber Forest Product (NTFP) resources on Nisga'a Lands and in the Nass Area (Chapter 5 of the NFA). All forest resources on Nisga'a Lands belong to the Nisga'a Nation. The Nisga'a Nation can make laws with regard to forest management, including forest health.

Pine mushrooms are harvested in many areas throughout Nisga'a Lands. NLG manages and regulates pine mushroom harvest within Nisga'a Lands by requiring all Nisga'a and non-Nisga'a harvesters to apply for a permit.

6.12.8.4.2 Aboriginal Groups

Potentially affected Aboriginal Groups have an interest in the health of terrestrial plants.

The Kitselas traditionally harvested and continue to harvest many plants. The Kitselas harvest from these areas from June to October and focus their harvest on huckleberries, blueberries, salmon berries, raspberries, thimbleberries, devil's club, mushrooms, and skunk cabbage.

Previous Kitsumkalum land use involved gathering berries, fruits and tree items, and agricultural cultivation of certain foods. Wood products were also collected for carving totem poles, building homes, and creating traditional art and utensils.

Coastal Tsimshian (including Metlakatla) traditionally harvested ripening salmonberries, soapberries, high bush cranberries, and wild crab-apples during the late summer months. Some of these berries were dried, while others were stored in grease.

The Gitanyow *wilp* have and continue to harvest a variety of flora species for sustenance, trading, revenue, and construction purposes. Of particular importance to the Gitanyow *wilp* are pine mushrooms, red cedar, and Old Growth Management Areas (OGMAs). While Gitanyow pine mushroom harvesting is a recent land use activity, it is an important source of annual income. Most harvesting of mushrooms occurs around the village of Gitanyow with non-motorised access by foot or bike. Also, members of *wilp* Watakhayetsxw harvest mushrooms in and around Jack Pine Mountain. Red cedar is an important construction material for houses, totem poles, household supplies, and clothing, which was used in trade with other Aboriginal groups for oolichan.

In summer and fall, the Gitxsan gathered berries, bark, and roots. Berry patches and salmon fishing places are important sites to Gitxsan. Management of berry patches entailed burning to improve productivity.

6.12.8.5 Past, Present, or Future Projects / Activities That May Interact With VC #7

The current assessment evaluates future ecological health risks potentially associated with the proposed Project, relative to baseline conditions that, by definition, would include any past or present projects in the vicinity. The following will be considered for the assessment:

- **Historical land use,** including previous mining and exploration activities and construction of the Kitsault Townsite, which is located 5 km from the proposed Project;
- **Current land use,** including nearby transportation and access roads, ongoing mining exploration, trapping and guide outfitting, marine boat traffic, and recreational fishing; and
- **Future land use,** including the NTL Project.

6.12.8.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to the environmental health since they could adversely affect the long-term health of vegetation. Emphasis is placed on identifying metals as COPCs, since metals usually pose the most potential for adverse health risks at mines. Mining projects often have high metal concentrations and volumes in mining wastes and dust generated from mining activities, and which often persist in the environment. The environmental health component provides information, including chemical analyses, modelling results, and data through exposure modelling calculations to assess effects on the health of the vegetation.

6.12.8.6.1 Identification and Analysis of Potential Project Cumulative Effects

Ecological COPCs have been identified by screening the 95th percentile concentrations for soil against CCME guidelines (or other toxicity-based guidelines as appropriate) and local background concentrations. Baseline soil concentrations have been used to screen for soil because proposed Project effects data were not available for the assessment. Chemicals were assessed in the ERA if the 95th percentile concentration exceeded the relevant guideline, or the detection limit exceeded the guideline. The results of the COPC screening are summarised in Table 6.12.8-2.

For the purpose of the ERA, the proposed Project is considered to be "residential / parkland." The site is considered to represent residential / parkland land use because: (1) it is an environment dominated primarily of open woodland areas and barren areas; and (2) it is expected to provide habitat for ecological receptors.

Table 6.12.8-2: Screening of Chemicals of Potential Concern in Soil for Terrestrial Plants

Metal COPC	Soil Milligrams per Kilogram (mg/kg)		
	95th Percentile of Baseline Soil Concentrations (a)	Screening Guideline	
		CCME (b)	Government of BC (c)
Aluminum	44275	n/a	n/a
Antimony	5.0	20	20
Arsenic	29.0	17	n/a
Barium	175.5	500	n/a
Beryllium	0.84	4	4
Cadmium	0.97	10	n/a
Chromium	97.0	64	n/a
Cobalt	26.2	50	50
Copper	49.2	63	n/a
Lead	48.0	140	n/a
Manganese	3272	n/a	n/a
Mercury	0.25	6.6	n/a
Molybdenum	94.9	10	10
Nickel	99.4	50	100
Selenium	1.4	1	3
Silver	7.2	20	20
Strontium	36.1	n/a	n/a
Thallium	0.5	1	n/a
Tin	7.7	n/a	50
Vanadium	98.1	130	200
Zinc	163.5	200	n/a

Note: BC - British Columbia; CCME - Canadian Council of Ministers of the Environment; COPC - Chemical of Potential Concern; mg/kg - milligrams per kilogram; n/a - not applicable (a) 95th percentile of baseline soil concentrations. Concentrations provided by Rescan and AMEC Soil Quality Group. (b) Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guideline for the protection of Environmental Health" (CCME 2007). Value represents guideline protective of residential / parkland uses. (c) BC *Environmental Management Act*, *Contaminated Sites Regulation*, Schedule 4 Numeric Soil Standards. Highlighted cell indicates metal is a COPC in specified medium. Metal was selected as a COPC: in soil if the 95th percentile of the concentration exceeded screening guideline for soil.

Screening for Soil

Analytical chemistry data for soil were assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- BC *CSR* of the BC *EMA*, Schedule 4 Generic Numerical Soil Standards, for park and residential use; and
- Canadian Environmental Quality Guidelines: "Canadian Soil Quality Guidelines for the Protection of Environmental Health" (CCME 2011), assuming a residential / parkland land use.

Based on the screening conducted for soil concentrations, the following chemicals have been identified as COPCs in soil and were carried forward in the ERA for the proposed Project:

- Arsenic;
- Chromium;
- Molybdenum;
- Nickel; and
- Selenium.

The remaining COPCs found in soil are below their respective guidelines and have not been carried forward in the assessment.

Exposure Assessment

The exposure assessment includes an analysis of the pathways through which VCs may be exposed to COPCs and an estimate of the concentrations to which they may be exposed. For COPCs to have deleterious effects on ecological receptors, the COPC must have contact with the organism or receptor. The route by which this occurs is referred to as an exposure pathway and is dependent on the nature of the chemical and the nature of the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of COPCs must be present;
- Release and transport mechanisms and media must be available to move the COPC from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the COPC is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

Pathway Analysis

Root Uptake

Plants are potentially exposed to COPCs via root uptake and, in some cases, foliar uptake. Root uptake is the primary route of exposure for terrestrial plants.

For metals and metalloids, root uptake is partly determined by chemical characteristics determining the mobility of the element in the soil environment, partly by soil characteristics (e.g., pH, clay, organic matter content and type, and moisture content), and partly by the selective absorption from soil solution by the root. Many metals and metalloids tend to be taken up easily through plant roots if dissolved in water. Metals may be taken up passively with the mass flow of water into roots, or by membrane transport systems responsible for uptake of nutrient elements. Depending on the metal's chemical properties, it can be translocated via the vascular system to most areas of the plant.

For root uptake to occur, roots must make contact with contaminants in soil pore water. Therefore, rooting depth is a major factor limiting uptake. Although rooting depth varies among different plant species and according to soil properties (e.g., mechanical resistance, aeration, fertility, moisture), relatively few plant species have rooting depths greater than 1 m, and in most natural ecosystems the majority of root mass is contained in the upper 0.5 m depth (Suter et al. 2000). Even large, mature trees in temperate climates do not typically have tap root systems extending to great depths. A large data set of root dimensions on windthrown trees (Gasson and Cutler 1990) revealed only 5% of mature trees extended roots below 2 m depth, and 90% to 99% of root mass was contained within the upper 1 m. Considering that elevated metal concentrations were noted in the shallow soil, uptake of metals from soil and groundwater is assumed to be a complete pathway for plants.

Exposure Estimates

Because terrestrial are immobile, exposure to contaminants cannot be averaged or integrated among areas of a site with higher and lower concentrations. Some fraction of individuals in a population at a site is potentially exposed to the highest concentrations of COPCs. Therefore, exposure estimates are based on upper estimates of concentrations at the proposed Project site. Although the maximum measured concentration can be used as a very conservative estimate of exposure, use of the maximum would ensure protection of 100% of individuals, which is not consistent with the objectives of the assessment or standard practice in the ERA. Instead, the 95th percentile of the distribution of COPC concentrations is used as an estimate of exposure (Table 6.12.8-3). Use of the 95th percentile describes the use of a concentration that is 95% of the maximum concentration sampled or modelled.

Table 6.12.8-3: Ecological Risk 95th Percentile Concentrations for Soil

Metal COPC	95th Percentile Soil Concentrations (mg/kg)
Arsenic	29.0
Chromium	97.0
Molybdenum	95.0
Nickel	99.5
Selenium	1.14

Note: COPC - Chemical of Potential Concern; mg/kg - milligram per kilogram

Toxicity Assessment

For vegetation, TRVs representing concentrations of COPCs in the soil that would not result in adverse health effects have been identified:

Arsenic

Arsenic is not essential for plant growth. Roots take it up actively, with arsenate being more easily absorbed than arsenite. The phytotoxicity of arsenic is strongly affected by the form in which it occurs in soils. Arsenite is more toxic than arsenate, and both are considerably more toxic than organic forms (Peterson et al. 1981). Symptoms of arsenic toxicity include wilting of new-cycle leaves, followed by retardation of root and top growth, and leaf necrosis (Aller et al. 1990). Arsenic (III) probably reacts with sulphydryl enzymes, leading to membrane degradation and cell death. Arsenic (V) is known to uncouple phosphorylation and affect enzyme systems (Peterson et al. 1981). The mechanism of toxicity of organo-arsenicals is unclear. An average toxicity threshold of 40 mg/kg was established for crop plants (Sheppard et al. 1992).

Rosehart and Lee (1973) tested the tolerance of spruce seedlings to arsenic in field plots. Three-year-old seedlings were grown for 335 days in soil to which 1000 ppm arsenic was added as arsenic (III) (lowest concentration tested). A 50% reduction in the height of the seedlings was observed.

Jiang and Singh (1994) assessed the toxicity of arsenic (III) and arsenic (V) on barley and ryegrass yields. The plants were grown from seed for one year in two different soils in a greenhouse. The soils tested were a loam (pH 4.9, 3% organic carbon, and 19% clay) and a sand (pH 5.6, 0.4% organic carbon, and 3% clay). Sodium arsenite was more toxic to barley plants than sodium arsenate in both soils. Barley seedlings exhibited the greatest toxicity when grown in the sand (24% decrease at 2 ppm, the lowest concentration tested). Arsenic (V) at 250 ppm was associated with a greater reduction in ryegrass yield (63%) than the same concentration of arsenic (III) in the loam soil (22%). In the sand, sodium arsenite reduced ryegrass yield 34% at 50 ppm. A concentration of 250 ppm arsenic (V) caused a 91% decrease in yield while 50 ppm had no effect.

The CCME's SQG_E of 17 mg/kg for residential / parkland use has been adopted as the TRV for plants (CCME 1997b). This guideline is intended to protect plants and other terrestrial biota from direct soil contact at a level consistent with the purposes of a residential / parkland property.

Chromium

Sample et al. (1996) uses a screening benchmark value for chromium in terrestrial plants of 1 mg/kg. This value was adopted as the TRV. The screening benchmark is intended to protect plants and other terrestrial biota from direct soil contact.

Molybdenum

Sample et al. (1996) uses a screening benchmark value for molybdenum in terrestrial plants of 2 mg/kg. This value has been adopted as the TRV. The screening benchmark is intended to protect plants and other terrestrial biota from direct soil contact.

Nickel

Sample et al. (1996) provides a screening benchmark value for nickel in terrestrial plants of 30 mg/kg. This value was adopted as the TRV. The screening benchmark is intended to protect plants and other terrestrial biota from direct soil contact.

Selenium

In plants, selenium is an essential element for growth. In the environment, uptake and accumulation by plants is influenced by the concentration and form of selenium present in soils (Neal 1990). The most bio-available forms of selenium are considered to be those fractions which are soluble (McNeal and Balistrieri 1989). Other factors that influence selenium content in plants include pH, soil mineralogical composition, and plant species (Neal 1990).

Sample et al. (1996) provides a screening benchmark value for selenium in terrestrial plants of 1 mg/kg. This value was adopted as the TRV. The screening benchmark is intended to protect plants and other terrestrial biota from direct soil contact.

Risk Characterisation

Determining ERs involves a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure Ratio} = \frac{\text{Exposure Estimate}}{\text{TRV}}$$

ERs are interpreted as follows:

If the ER is less than 1, no unacceptable risks to Terrestrial Plants would be expected because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds 1, it may be inferred that adverse effects to individuals are possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV that was based on a 25% reduction in a growth-based endpoint (ER>1), it can be inferred that one possible outcome may be diminished growth of individuals in a population. This can potentially (but not necessarily) lead to a reduction in population abundance of that receptor. It is important to note that exceeding an ER of 1 does not necessarily mean that adverse effects will definitively occur; rather, it suggests that there is a lower confidence that adverse effects will not occur. It is also important to recognise that the magnitude of ERs is not directly associated with the magnitude of potential effects. That is, a large ER (>10) should not be interpreted as a 10-fold greater risk than an ER of 1.

For those COPCs with ERs greater than 1, potential risks at a population level cannot be ruled out and should be evaluated further. Evidence from sources other than chemical analysis may be employed, including evidence of toxicity at the proposed Project site, toxicity of media in laboratory exposures (i.e., bioassays), the absence of species formerly present or commonly found at similar sites, or diminished populations compared to a reference location.

Quantitative Interpretation of Risk Hazard

Risks to terrestrial plants exposed to COPCs in soil have been characterised by comparing 95th percentile concentrations of COPCs in soil to TRVs for terrestrial plants. The effects of the proposed Project on terrestrial plants are not expected to change from baseline risks since the COPC soil concentrations are not expected to change. Baseline soil concentrations have been collected, and have been used as the basis for the PQRA and the assessment completed presented in this section. The baseline is representative of the existing brownfield conditions and has been considered representative of soil conditions and COPCs concentrations at the time of proposed Project closure. . The ER for all COPCs (i.e., arsenic, chromium, molybdenum, nickel, and selenium) exceeded 1 (Table 6.12.8-4).

Table 6.12.8-4: Risk Estimates for Terrestrial Plants

COPC	Exposure Estimate (mg/kg/d)	TRV (mg/kg/d)	Exposure Ratio
Arsenic	29.0	17	1.7
Chromium	97.0	1	97.0
Molybdenum	94.9	2	47.5
Nickel	99.4	30	3.3
Selenium	1.4	1	1.4

Note: COPC - Chemical of Potential Concern; mg/kg/d - milligrams per kilograms per day; TRV - Toxicological Reference Value

It may be inferred from these results that levels of certain inorganic parameters in soil may pose a risk to terrestrial plants. However, as discussed previously, an ER greater than 1 does not indicate adverse effects are certain. ERs for immobile plants are based on the 95th percentile of COPC concentrations, an approach designed to ensure conservatism in the screening assessment. Concentrations at the majority of sampling locations were likely below levels capable of causing adverse effects for most COPCs. In all likelihood, adverse effects from elevated concentrations of COPCs would not be observed across most of the proposed Project site and, if present, would likely be limited to small areas in the vicinity of "hot spots." Therefore, although some effects may be possible, significant effects to the plant community from COPCs in soil are unlikely. The absence of documented phytotoxicity at the proposed Project site supports this conclusion.

6.12.8.7 Limitations

Assessing health risks from environmental chemicals is always associated with uncertainty. Where there is uncertainty, conservative assumptions have been used to ensure that risks are not underestimated (and in fact almost certainly overestimated). In the exposure assessment, uncertainty relate to the assumptions regarding the presence of VCs. Conservative assumptions have been made to ensure any ecological receptors that might be present in the vicinity of the proposed Project site are provided sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, which is why there is some uncertainty associated with TRVs. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs). This is because most reference values are based on the most sensitive species tested or a similar low effect level (e.g., 10th or 25th percentile of species sensitivity distribution), and toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e., the use of soluble metal salts).

For risk characterisation, the ERs generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring. There is greater inherent uncertainty associated with results of screening level assessments than higher-tier assessments because results are based primarily on modelled or estimated concentrations and TRVs derived from literature studies, rather than direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure were made and no toxicity studies were performed. In many cases, toxicity at a site is considerably diminished compared to effects predicted from laboratory studies, for a variety of reasons. Higher-tier assessments (i.e., Preliminary Quantitative ERA) incorporate site-specific toxicity data in a lines-of-evidence approach, which can reduce the level of uncertainty in this phase of the assessment.

6.12.8.8 Conclusion

Quantitative estimates of risk were calculated using a quotient approach in which exposure estimates based on 95th percentile concentrations have been compared to TRVs derived for each receptor / pathway. ERs greater than 1 are found for terrestrial plants exposed to arsenic, chromium, molybdenum, nickel, and selenium via direct contact with soil (Table 6.12.8-4).

For terrestrial plants, risk estimates for the proposed Project are the same and do not differ from the baseline. Baseline data was used in the assessment because proposed Project effects data for soil was unavailable. Therefore, the risks in this ERA for terrestrial plants are more representative of baseline conditions rather than proposed Project effects. It is currently not possible to predict whether the proposed Project will have an effect on the health of terrestrial plants since no Project-specific concentrations for soil are available for analysis.

6.12.9 VC #8: Aquatic Invertebrates

6.12.9.1 Introduction

Aquatic invertebrates have been included as a VC to address concerns that their health could be adversely affected by chemicals introduced or mobilised in the environment as a result of the proposed Project.

Aquatic Invertebrates

Aquatic and benthic invertebrates are an important group of organisms in most freshwater systems. Benthic macro-invertebrates (BMIs) serve as prey for many fish species and are critical for the proper functioning of aquatic ecosystems. Aquatic invertebrates are in direct contact with surface water. Benthic invertebrates are in direct contact with sediments and pore water, and as such, receive more exposure to sediment-borne contaminants than any other group. Additionally, invertebrates as a group tend to be one of the most sensitive to environmental contaminants, so protection of invertebrates also tends to result in protection of other species.

Invertebrates are often used as “indicators” of environmental degradation because of their rapid and predictable response to various environmental contaminants and other stressors.

Aquatic and benthic invertebrates are a critical source of food for predatory fish such as the trout. Aquatic invertebrates may potentially be exposed to COPCs in surface water while benthic invertebrates may be exposed to COPCs in sediment and pore water. Since pore water data was not available at the time of the assessment, metal toxicity to benthic invertebrates has not been evaluated in this ERA.

6.12.9.1.1 Relevant Legislation and Legal Framework

The ERA has been completed according to accepted (ERA) methodologies and guidance published by regulatory agencies including CCME (1996a, 1997), BC MOE (1998), and US EPA (1998).

6.12.9.1.2 Spatial Boundaries

The LSA and RSA are based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range, and activities that would bring the receptor into contact with various environmental media. In any population of organisms, there was extensive variability among individuals for each of these parameters. For aquatic invertebrates, the LSA and RSA would be similar to that of the air quality study areas. The air quality discipline (Section 6.2) defines the LSA as 2 km wide surrounding the proposed Project footprint and the RSA as 2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).

6.12.9.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project, which are contingent on permitting, include four primary phases:

1. Construction Phase – estimated 25-month period. This includes:
   - Site clearing and preparation, earthworks such as excavating and site grading;
   - Construction of mine site roads and power distribution lines on the site;
   - Facilities, such as processing plant, TMF starter embankment, reclaim pipe works;
   - Camp complex; and
   - May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).
2. Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years would be spent milling low-grade ore). This includes progressive reclamation.

3. Decommissioning and Closure Phase – estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase – estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse effects on local receiving waters. Stabilisation of the WRMF and TMF will also be considered in post-closure monitoring.

6.12.9.2 Information Source and Methods

Environmental chemistry data was obtained from the surface water quality discipline and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Water Quality Guidelines for the Protection of Aquatic Life" (CCME 2007).
- Ecological health risks were assessed by following Ecological Risk Assessment guidance materials recommended by the BC MOE (1998), CCME (1996a, 1997), and US EPA (1998).

6.12.9.3 Baseline Description of VC #8: Aquatic Invertebrates

The Environmental Health Baseline Report (Appendix 6.12-A) summarises the baseline health risks for aquatic invertebrates in the vicinity of the proposed Project.

The baseline prediction was completed using site soils and water quality data as a representation of site conditions prior to the onset of the proposed Project. The baseline data are to be compared to the effects assessment that used water quality data modelled for the construction, operations, and closure / decommissioning phases of the proposed Project.

Risks to aquatic invertebrates have been characterised by comparing the 95th percentile of surface water for each COPC to TRVs for the aquatic invertebrates. The cadmium ER for aquatic invertebrates exceeded 1 while the molybdenum ER is below 1 (Table 6.12.9-1).

Table 6.12.9-1: Baseline Risk Estimates for Aquatic Invertebrates

COPC	Exposure Estimate (mg/L)	TRV (mg/L)	Exposure Ratio
Cadmium	0.0010	0.008	1.4
Molybdenum	0.322	0.37	0.37

Note: COPC - Chemicals of Potential Concern; mg/L - milligrams per litre; TRV - Toxicological Reference

6.12.9.4 Cultural Ecological or Community Knowledge

6.12.9.4.1 Nisga'a Nation

Desk-based research and engagement activities with the Nisga'a Nation did not indicate any specific concern or issue with aquatic invertebrates. Ongoing consultation with the Nisga'a Nation may provide additional information and insight into the value and interests of the health of aquatic invertebrates related to the proposed Project.

6.12.9.4.2 Aboriginal Groups

Desk-based research and engagement activities with potentially affected Aboriginal groups did not indicate any specific concern or issue with aquatic invertebrates. Ongoing consultation with Aboriginal groups may provide additional information and insight into the value and interests of the health of aquatic invertebrates related to the proposed Project.

6.12.9.5 Past, Present, or Future Projects / Activities That May Interact With VC #8

The current assessment evaluates future ecological health risks potentially associated with the proposed Project, relative to baseline conditions that, by definition, would include any past or present projects in the vicinity. The following will be considered for the assessment;

- **Historical land use,** including previous mining and exploration activities and construction of the Kitsault Townsite, which is located 5 km from the proposed Project;
- **Current land use,** including nearby transportation and access roads, ongoing mining exploration, trapping and guide outfitting, marine boat traffic, and recreational fishing; and
- **Future land use,** including the NTL Project.

6.12.9.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to environmental health since they could adversely affect the long-term health of aquatic invertebrates. Emphasis is placed on identifying metals as COPCs, since metals usually pose the most potential for adverse health risks at mines. Mining projects often have high metal concentrations and volumes in mining wastes and dust generated from mining activities, and which often persist in the environment. The environmental health component provides information, including chemical analyses and modelling results, and data through exposure modelling calculations to assess effects on the health of aquatic invertebrates.

6.12.9.6.1 Identification and Analysis of Potential Project Cumulative Effects

Ecological COPCs have been identified by screening the 95th percentile concentrations for surface water against CCME guidelines (or other toxicity-based guidelines as appropriate) and local background concentrations. Chemicals were assessed in the ERA if the 95th

percentile concentration exceeded the relevant guideline, or the detection limit exceeded the guideline. The results of the COPC screening are summarised in Table 6.12.9-2.

Table 6.12.9-2: Screening of Chemicals of Potential Concern in Surface Water for Aquatic Invertebrates

Metal COPC	Screening Guideline for Surface Water	
	95th Percentile Concentrations for Surface Water (mg/L) (a)	Freshwater Aquatic Life Health
Antimony	0.02	0.02 (c)
Arsenic	0.013	0.005 (b)
Barium	0.056	5 (c)
Beryllium	0.0007	0.0053 (d)
Cadmium	0.0029	0.00017 (b)
Chromium	0.0015	0.001 (c)
Cobalt	0.00034	0.11 (c)
Copper	0.012	0.002 (b)
Lead	0.011	0.001 (b)
Mercury	0.00019	0.000026 (b)
Molybdenum	1.6	0.073 (b)
Nickel	0.028	0.025 (b)
Selenium	0.015	0.002 (b)
Silver	0.00006	0.0015 (b)
Thallium	0.00011	0.0003 (d)
Vanadium	0.003	0.006 (d)
Zinc	0.065	0.033 (b)

Note: BC - British Columbia; COPC - Chemical of Potential Concern; mg/L - milligrams per litre; n/a - not applicable (a) 95th percentile of project effects surface water concentrations (all project phases). Concentrations provided by AMEC Water / Sediment Quality Group. (b) CCME Canadian Environmental Quality Guidelines: "Canadian Water Quality Guideline for the Protection of Aquatic Life" (CCME 2007). (c) BC Water Quality Guideline (maximum) for the Protection of Freshwater Aquatic Life (Government of BC 2011). (d) BC Water Quality Guideline (30-day average) for the Protection of Freshwater Aquatic Life (Government of BC 2011). Highlighted cell indicates metal is a COPC in specified medium for ecological risk assessment. Metal was selected as a COPC in water if the 95th percentile concentration exceeded screening guideline in water.

Screening for Surface Water

The reported concentration data for surface water has been assessed and evaluated for the purposes of identifying COPCs using:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Water Quality Guidelines for the Protection of Aquatic Life" (CCME 2011).

Summary of Identified COPCs

Based on the screening conducted for surface water concentrations (Table 6.12.9-2), the following compounds are identified as COPCs in surface water for aquatic invertebrates, and are carried forward in the ERA for the proposed Project:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Lead;
- Mercury;
- Molybdenum;
- Nickel;
- Selenium; and
- Zinc.

The remaining COPCs found in surface water are below their respective guidelines for aquatic invertebrates and have not been carried forward in the assessment.

Exposure Assessment

The exposure assessment includes an analysis of the pathways through which VCs may be exposed to COPCs and an estimate of the concentrations to which they may be exposed. For COPCs to have deleterious effects on ecological receptors, the COPC must have contact with the organism or receptor. The route by which this occurs is referred to as an exposure pathway and is dependent on the nature of the chemical and the nature of the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of COPCs must be present;
- Release and transport mechanisms and media must be available to move the COPC from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the COPC is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

Pathway Analysis

Direct Exposure of Aquatic Invertebrates to COPCs in Surface Water

Uptake from surface water is a major exposure pathway for aquatic invertebrates. Aquatic invertebrates accumulate and transfer COPCs up the food chain. Aquatic invertebrate organisms are exposed to COPCs through the water column.

Exposure Estimates

The 95th percentile concentrations in the surface water media used for aquatic invertebrates are presented in Table 6.12.9-3.

Table 6.12.9-3: Ecological Risk 95th Percentile Concentrations for Surface Water

Metal COPC	95th Percentile Surface Water Concentration (mg/L)
Arsenic	0.0129
Cadmium	0.0029
Chromium	0.0015
Copper	0.012
Lead	0.011
Mercury	0.00019
Molybdenum	1.61
Nickel	0.0282
Selenium	0.016
Zinc	0.065

Note: COPC - Chemical of Potential Concern; mg/L - milligram per litre

Toxicity Assessment

For aquatic invertebrates, TRVs representing concentrations of COPCs in the various environmental media that would not result in adverse health effects were presented in Table 6.12.9-4.

Table 6.12.9-4: Toxicological Reference Values for Aquatic Invertebrates

Metal COPC	TRV (mg/L)	Reference
Arsenic	0.450	Sample et al. (1996). Based on estimated chronic value with *Daphnia magna*.
Cadmium	0.0008	Carlson et al. (1982). Based on life-cycle chronic test on *Daphnia magna*.
Chromium	0.044	Sample et al. (1996). Based on life-cycle chronic test on *Daphnia magna.*

Metal COPC	TRV (mg/L)	Reference
Copper	0.00023	Sample et al. (1996). Based on life-cycle chronic test on *Daphnia magna.*
Lead	0.0123	Sample et al. (1996). Based on life-cycle chronic test on *Daphnia magna.*
Mercury	0.0096	Sample et al. (1996). Based on life-cycle chronic test on *Daphnia magna.*
Molybdenum	0.88	Sample et al. (1996). Based on life-cycle chronic test on *Daphnia magna.*
Nickel	0.005	Sample et al. (1996). Based on life-cycle chronic test on *Daphnia magna.*
Selenium	0.0917	Sample et al. (1996). Based on life-cycle chronic test on *Daphnia magna.*
Zinc	0.0047	Sample et al. (1996). Based on life-cycle chronic test on *Daphnia magna.*

Note: COPC - Chemical of Potential Concern; mg/L - milligrams per litre; TRV - Toxicological Reference Value

Risk Characterisation

Determining ERs involves a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure Ratio} = \frac{\text{Exposure Estimate}}{\text{TRV}}$$

ERs are interpreted as follows:

If the ER is less than 1, no unacceptable risks to Aquatic Invertebrates would be expected, because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds 1, it may be inferred that adverse effects to individuals are possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV that was based on a 25% reduction in a growth-based endpoint (ER>1), it can be inferred that one possible outcome may be diminished growth of individuals in a population. This can potentially (but not necessarily) lead to a reduction in population abundance of that receptor. It is important to note that exceeding an ER of 1 does not necessarily mean that adverse effects will definitively occur; rather, it suggests that there is a lower confidence that adverse effects will not occur. It is also important to recognise that the magnitude of ERs is not directly associated with the magnitude of potential effects. That is, a large ER (>10) should not be interpreted as a 10-fold greater risk than an ER of 1.

For those COPCs with ERs greater than 1, potential risks at a population level cannot be ruled out and should be evaluated further. Evidence from sources other than chemical analysis may be employed, including toxicity of media in laboratory exposures (i.e., bioassays), the absence of species formerly present or commonly found at similar sites, or diminished populations compared to a reference location.

Quantitative Interpretation of Risk Hazard

Risks to aquatic invertebrates exposed to COPCs in surface water have been characterised by comparing exposure estimates for each COPC to TRVs for aquatic invertebrates. ERs for cadmium, copper, molybdenum, nickel, and zinc exceeded 1 for aquatic invertebrates while ERs for the remaining COPCs were below 1. Risk estimates for aquatic invertebrates are presented in Table 6.12.9-5.

Table 6.12.9-5: Risk Estimates for Aquatic Invertebrates

COPC	Exposure Estimate (mg/L)	TRV (mg/L)	Exposure Ratio
Aquatic Invertebrates			
Arsenic	0.0129	0.45	0.029
Cadmium	0.0029	0.0008	3.9
Chromium	0.0015	0.073	0.034
Copper	0.012	0.0002	6.3
Lead	0.011	0.012	0.88
Mercury	0.00019	0.0010	0.20
Molybdenum	1.61	0.88	1.8
Nickel	0.0282	0.0050	5.6
Selenium	0.016	0.092	0.17
Zinc	0.065	0.0047	13.9

Note: COPC - Chemicals of Potential Concern; mg/L - milligrams per litre; TRV - Toxicological Reference Value

Risk estimates for the proposed Project effects differ from the baseline. ERs have been observed to be higher in the effects assessment when compared to the baseline.

6.12.9.7 Limitations

Assessing health risks from environmental chemicals is always associated with uncertainty. Where there is uncertainty, conservative assumptions have been used to ensure that risks were not underestimated (and in fact almost certainly overestimated). In the exposure assessment, uncertainty relate to the assumptions regarding the presence of VCs. Conservative assumptions have been made to ensure any ecological receptors that might be present in the vicinity of the proposed Project site are provided sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, which is why there is some uncertainty associated with TRVs. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs). This is because most reference values are based on the most sensitive species tested or a similar low effect level (e.g., 10^{th} or 25^{th} percentile of species sensitivity distribution), and toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e., the use of soluble metal salts).

For risk characterisation, the ERs generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring. There is greater inherent uncertainty associated with results of screening level assessments than higher-tier assessments, because results are based primarily on modelled or estimated concentrations and TRVs derived from literature studies, rather than direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure have been made and no toxicity studies have been performed. In many cases, toxicity at a site is considerably diminished compared to effects predicted from laboratory studies, for a variety of reasons. Higher-tier assessments (i.e., Preliminary Quantitative ERA) incorporate site-specific toxicity data in a lines-of-evidence approach, which can reduce the level of uncertainty in this phase of the assessment.

6.12.9.8 Conclusion

Quantitative estimates of risk have been calculated using a quotient approach in which exposure estimates based on 95^{th} percentile concentrations were compared to TRVs derived for each receptor / pathway. ERs greater than 1 were found for aquatic invertebrates exposed to cadmium, copper, molybdenum, nickel, and zinc via direct contact with surface water while ERs for all remaining COPCs were below 1 (Table 6.12.9-5).

Risk estimates for the proposed Project differ from the baseline. For aquatic invertebrates, ERs for certain COPCs are higher in the effects assessment when compared to the baseline. Proposed Projects effects surface water data (i.e., construction, operations, closure and post-closure) used in the ERA may have contributed in the change in ERs from baseline assessment to effects assessment.

6.12.10 VC #9: Aquatic Plants

6.12.10.1 Introduction

Aquatic plants have been included as a VC to address concerns that their health could be adversely affected by chemicals introduced or mobilised in the environment as a result of the proposed Project.

Aquatic plants, including algae, play an important role in most freshwater systems, oxygenate water, and form the basis of the aquatic food chain. Existing in a variety of forms, aquatic plants are found as submerged, emergent, and free-floating forms.

Submerged macrophytes provide habitat / cover for a variety of fish. Emergent forms, such as cattails, bullrushes, and reeds, are used by birds for cover and food. Plants are not especially sensitive to bioaccumulative substances, but are sensitive to toxicity from some metals. Aquatic plants were evaluated as a group rather than as individual species.

6.12.10.1.1 Relevant Legislation and Legal Framework

The ERA has been completed according to accepted (ERA) methodologies and guidance published by regulatory agencies, including CCME (1996a, 1997), BC MOE (1998), and US EPA (1998).

6.12.10.1.2 Spatial Boundaries

Spatial boundaries for the risk assessment corresponded to the spatial boundaries of other environmental disciplines as necessary. The LSA and RSA are based on chemical concentrations in the environmental exposure media, bioavailability, life expectancy, home range, and activities that would bring the receptor into contact with various environmental media. In any population of organisms, there was extensive variability among individuals for each of these parameters. For aquatic plants, the LSA and RSA would be similar to that of the air quality study areas. The air quality discipline (Section 6.2) defines the LSA as 2 km wide surrounding the proposed Project footprint and the RSA as 2.5 km beyond the LSA and 4.5 km from the surrounding footprint of the proposed Project (Figure 6.12.2-1).

6.12.10.1.3 Temporal Boundaries

Temporal boundaries for the risk assessment correspond to the phases of the proposed Project, as described in Section 3.0 (Project Description).

Preliminary temporal boundaries of the proposed Project, which are contingent on permitting, include four primary phases:

1. Construction Phase – estimated 25-month period. This includes:
    - Site clearing and preparation, earthworks such as excavating and site grading;
    - Construction of mine site roads and power distribution lines on the site;
    - Facilities, such as processing plant, TMF starter embankment, reclaim pipe works;
    - Camp complex; and
    - May include the Patsy Creek diversion (this may be scheduled during the operations phase depending on environmental and project feasibility considerations).
2. Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining (last two years would be spent milling low-grade ore). This includes progressive reclamation.

3. Decommissioning and Closure Phase – estimated at 15 to 17 years. This includes a closure period during which the buildings and decommissioned infrastructure will be removed and mine facilities reclaimed.
4. Post-Closure Phase – estimated at five years or more. This includes post-closure monitoring until on-site water quality has stabilised and indicates no future adverse effects on local receiving waters. Stabilisation of the WRMF and TMF will also be considered in post-closure monitoring.

6.12.10.2 Information Source and Methods

Environmental chemistry data was obtained from the surface water discipline. Analytical chemistry data for surface water are assessed and evaluated using the following federal and provincial regulatory guidelines for the purposes of identifying COPCs:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Water Quality Guidelines for the Protection of Aquatic Life" (CCME 2007).

Ecological health risks were assessed by following Ecological Risk Assessment guidance materials recommended by the BC MOE (1998), CCME (1996a, 1997), and US EPA (1998).

No information is available for appropriate TRVs for metal exposures to aquatic plants. Test studies and toxicological benchmarks for algae are available and commonly utilized by risk assessors since toxicological effects would be similar and since algae is more often used as a monitoring tool due to the quality of species and its ubiquitous presence in the ecosystem. Ecologically, algae are the most widespread of the photosynthetic plants. Algae and macrophytes are, on a cellular level, similar in nature as both have photosynthetic properties (Hasan, R.M. 2009).

6.12.10.3 Description of VC #9: Aquatic Plants

The Environmental Health Baseline Report (Appendix 6.12-A) summarises the baseline health risks for aquatic plants in the vicinity of the proposed Project.

The baseline prediction was completed using water quality data as a representation of site conditions prior to the onset of the proposed Project. The baseline data are to be compared to the effects assessment that used water quality data modelled for the construction, operations, and decommissioning / closure of the proposed Project.

Risks to aquatic plants are characterised by comparing the 95^{th} percentile of surface water for each COPC to TRVs for the aquatic plants. Exposure ratios for COPCs for aquatic plants are below one (Table 6.12.10-1).

Table 6.12.10-1: Baseline Risk Estimates for Aquatic Plants

COPC	Exposure Estimate (mg/L)	TRV (mg/L)	Exposure Ratio
Cadmium	0.0010	0.0020	0.52
Molybdenum	0.322	0.88	0.37

Note: COPC - Chemical of Potential Concern; mg/L - milligrams per litre; TRV - Toxicological Reference

6.12.10.4 Cultural Ecological or Community Knowledge

6.12.10.4.1 Nisga'a Nation

The NFA defines Nisga'a rights to harvest aquatic plants, including kelp, marine flowering plants, benthic and detached algae, brown algae, red algae, green algae, and phytoplankton, in the Nass Area for domestic purposes within measures of conservation and public safety. The Nisga'a Nation has jurisdiction over the licensing, authorisation, methods, and locations of the harvest of aquatic plants by Nisga'a citizens. The NFA indicates that Canada, BC, and the Nisga'a Nation may establish an allocation of aquatic plants to further define the Nisga'a entitlement, which would take into consideration Nisga'a harvest, effect of conservation measures on Nisga'a harvest, and biological status of the Species. Aboriginal Groups

Desk-based research results indicate that Kitsumkalum members harvest and consume seaweed and kelp. In May, Metlakatla go to camps where seaweed is gathered and dried.

Desk-based research and engagement activities for the remaining three Aboriginal groups (i.e., Gitxsan Chiefs, Kitselas First Nation, and Gitanyow Hereditary Chiefs) did not indicate any specific concern or issue with aquatic plants. Ongoing consultation with Aboriginal groups may provide additional information and insight into the value and interests of the health of aquatic plants related to proposed Project.

6.12.10.5 Past, Present, or Future Projects / Activities That May Interact With VC #9

The current assessment evaluates potential ecological health risks associated with the proposed Project, relative to baseline conditions that by definition would include any past or present projects in the vicinity. The following will be considered for the assessment;

- **Historical land use,** including previous mining and exploration activities and construction of the Kitsault Townsite, which is located 5 km from the proposed Project;
- **Current land use,** including nearby transportation and access roads, ongoing mining exploration, trapping and guide outfitting, marine boat traffic, and recreational fishing; and
- **Future land use,** including the NTL Project

6.12.10.6 Potential Effects of the Proposed Project and Proposed Mitigation

COPCs associated with the proposed Project are relevant to environmental health since they could adversely affect the long-term health of aquatic plants. Emphasis is placed on identifying metals as COPCs, since metals usually pose the most potential for adverse health risks at mines. Mining projects often have high metal concentrations and volumes in mining wastes and dust generated from mining activities, and which can often persist in the environment. The environmental health component provides information, including chemical analyses and modelling results, and data through exposure modelling calculations to assess effects on the health of aquatic plants.

6.12.10.6.1 Identification and Analysis of Potential Project Cumulative Effects

Ecological COPCs have been identified by screening the 95th percentile concentrations for surface water against CCME guidelines (or other toxicity-based guidelines as appropriate) and local background concentrations. Chemicals have been assessed in the ERA if the 95th percentile concentration exceeded the relevant guideline, or the detection limit exceeded the guideline. The results of the COPC screening are summarised in Table 6.12.10-2.

Table 6.12.10-2: Screening of Chemicals of Potential Concern in Surface Water for Aquatic Plants

Metal COPC	Screening Guideline for Surface Water	
	95th Percentile Concentrations for Surface Water (mg/L) (a)	Freshwater Aquatic Life Health
Antimony	0.02	0.02 (c)
Arsenic	0.013	0.005 (b)
Barium	0.056	5 (c)
Beryllium	0.0007	0.0053 (d)
Cadmium	0.0029	0.00017 (b)
Chromium	0.0015	0.001 (c)
Cobalt	0.00034	0.11 (c)
Copper	0.012	0.002 (b)
Lead	0.011	0.001 (b)
Mercury	0.00019	0.000026 (b)
Molybdenum	1.6	0.073 (b)
Nickel	0.028	0.025 (b)
Selenium	0.015	0.002 (b)
Silver	0.00006	0.0015 (b)
Thallium	0.00011	0.0003 (d)
Vanadium	0.003	0.006 (d)
Zinc	0.065	0.033 (b)

Note: COPC - Chemical of Potential Concern; mg/L - milligrams per litre; n/a - not applicable (a) 95th percentile of project effects surface water concentrations (all project phases). Concentrations provided by AMEC Water / Sediment Quality Group. (b) CCME Canadian Environmental Quality Guidelines: "Canadian Water Quality Guideline for the Protection of Aquatic Life" (CCME 2007). (c) BC Water Quality Guideline (maximum) for the Protection of Freshwater Aquatic Life (Government of BC 2011). (d) BC Water Quality Guideline (30-day average) for the Protection of Freshwater Aquatic Life (Government of BC 2011). Highlighted cell indicates metal is a COPC in specified medium for ecological risk assessment. Metal was selected as a COPC in water if the 95th percentile concentration exceeded screening guideline in water.

Screening for Surface Water

The reported concentration data for surface water were assessed and evaluated for the purposes of identifying COPCs using:

- CCME's Canadian Environmental Quality Guidelines: "Canadian Water Quality Guidelines for the Protection of Aquatic Life" (CCME 2011).

Summary of Identified COPCs

Based on the screening conducted for surface water concentrations (Table 6.12.10-2), the following compounds are identified as a COPC in surface water for aquatic plants and are carried forward in the ERA for the proposed Project:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Lead;
- Mercury;
- Molybdenum;
- Nickel;
- Selenium; and
- Zinc.

The remaining COPCs found in surface water are below their respective guidelines for aquatic plants and have not been carried forward in the assessment.

Exposure Assessment

The exposure assessment includes an analysis of the pathways through which VCs may be exposed to COPCs and an estimate of the concentrations to which they may be exposed. For COPCs to have deleterious effects on ecological receptors, the COPC must have contact with the organism or receptor. The route by which this occurs is referred to as an exposure pathway and is dependent on the nature of the chemical and the nature of the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of COPCs must be present;
- Release and transport mechanisms and media must be available to move the COPC from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the COPC is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

Pathway Analysis

Direct Exposure of Aquatic Plants to COPCs in Surface Water

Uptake from surface water is a major exposure pathway for aquatic plants. Aquatic plants accumulate COPCs and are the source for the transfer of the COPCs up the food chain.

Aquatic plants take two forms: rooted to the sediment (submerged or emergent); and free-floating. Uptake in floating plants is limited to contaminants in surface water only, while rooted species may potentially take up contaminants from sediment as well as surface water. However, as most chemicals must be in the dissolved phase prior to root uptake, uptake from sediment actually occurs via the sediment pore water. Moreover, despite physiological differences between rooted aquatic plants and terrestrial plants, uptake from surface water is the major exposure pathway and more important than uptake from roots. In many species, roots primarily serve a physical role as anchors, rather than an organ by which nutrients (and contaminants) are taken up. Therefore, the dominant uptake pathway for metals into aquatic plants is the aqueous pathway.

Exposure Estimates

The 95th percentile concentrations in the surface water media used for aquatic plants are presented in Table 6.12.10-3.

Table 6.12.10-3: Ecological Risk 95th Percentile Concentrations for Aquatic Plants

Metal COPC	95th Percentile Surface Water Concentration (mg/L)
Arsenic	0.0129
Cadmium	0.0029
Chromium	0.0015
Copper	0.012
Lead	0.011
Mercury	0.00019
Molybdenum	1.61
Nickel	0.0282
Selenium	0.016
Zinc	0.065

Note: COPC - Chemical of Potential Concern; mg/L - milligram per litre

Toxicity Assessment

For aquatic plants, TRVs representing concentrations of COPCs in surface water that would not result in adverse health effects were presented in Table 6.12.10-4.

Table 6.12.10-4: Toxicological Reference Values for Aquatic Plants

Metal COPC	TRV (mg/L)	Reference
Arsenic	0.0048	Sample et al. (1996). Based on growth rate test.
Cadmium	0.0020	Conway (1977). Based on population growth rate test of *Asterionella formosa.*
Chromium	0.0020	Sample et al., (1996). Based on population growth rate test of *Microsystis aeruginosa.*
Copper	0.0010	Sample et al., (1996). Based on growth rate test of *Chlorella pyrenoidosa.*
Lead	0.50	Sample et al. (1996). Based on growth rate test of *Scenedesmus quadricauda.*
Mercury	0.005	Sample et al. (1996). Based on growth rate test of *Microsystis aeruginosa.*
Molybdenum	0.88	Sample et al. (1996). Value for all aquatic organisms.
Nickel	0.005	Sample et al. (1996). Based on population growth rate test of *Microsystis aeruginosa*
Selenium	0.10	Sample et al. (1996). Based on growth rate test of *Scenedesmus obliquus.*
Zinc	0.0030	Sample et al. (1996). Based on growth rate test of *Selanastrum capricornutum.*

Note: COPC - Chemical of Potential Concern; mg/L - milligrams per litre; TRV - Toxicological Reference Value

No information is available for appropriate TRVs for metal exposures to aquatic plants. Test studies and toxicological benchmarks for algae are available and commonly utilized by risk assessors since toxicological effects would be similar and since algae is more often used as a monitoring tool due to the quality of species and its ubiquitous presence in the ecosystem. Ecologically, algae are the most widespread of the photosynthetic plants. Algae and macrophytes are, on a cellular level, similar in nature as both have photosynthetic properties (Hasan, R.M. 2009).

Risk Characterisation

ERs are a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure Ratio} = \frac{\text{Exposure Estimate}}{\text{TRV}}$$

ERs are interpreted as follows:

If the ER is less than 1, no unacceptable risks to Aquatic Plants would be expected, because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds 1, it may be inferred that adverse effects to individuals are possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV that was based on a 25% reduction in a growth-based endpoint (ER>1), it can be inferred that one possible outcome may be diminished growth of individuals in a population. This can potentially (but not necessarily) lead to a reduction in population abundance of that receptor. It is important to note that exceeding an ER of 1 does not necessarily mean that adverse effects will definitively occur; rather, it suggests that there is a lower confidence that adverse effects will not occur. It is also important to recognise that the magnitude of ERs is not directly associated with the magnitude of potential effects. That is, a large ER (>10) should not be interpreted as a 10-fold greater risk than an ER of 1.

For those COPCs with ERs greater than 1, potential risks at a population level cannot be ruled out and should be evaluated further. Evidence from sources other than chemical analysis may be employed, including toxicity of media in laboratory exposures (i.e., bioassays), the absence of species formerly present or commonly found at similar sites, or diminished populations compared to a reference location.

Quantitative Interpretation of Risk Hazard

Risks to aquatic plants exposed to COPCs in surface water have been characterised by comparing exposure estimates for each COPC to TRVs for aquatic plants. ERs for arsenic, cadmium, copper, molybdenum, nickel, and zinc exceeded 1 for aquatic plants while ERs for remaining COPCs were below 1. Risk estimates for aquatic plants are presented in Table 6.12.10-5.

Table 6.12.10-5: Risk Estimates for Aquatic Plants

COPC	Exposure Estimate (mg/L)	TRV (mg/L)	Exposure Ratio
Aquatic Plants			
Arsenic	0.0129	0.0048	2.7
Cadmium	0.0029	0.0020	1.5
Chromium	0.0015	0.0020	0.75
Copper	0.012	0.0010	1.5
Lead	0.011	0.50	0.022
Mercury	0.00019	0.0050	0.038
Molybdenum	1.61	0.88	1.8
Nickel	0.0282	0.0050	5.6
Selenium	0.016	0.10	0.16

COPC	Exposure Estimate (mg/L)	TRV (mg/L)	Exposure Ratio
Zinc	0.065	0.0030	21.6

Note: COPC - Chemicals of Potential Concern; mg/L - milligrams per litre; TRV - Toxicological Reference Value

Risk estimates for the proposed Project effects differ from the baseline. ERs are observed to be higher in the effects assessment when compared to the baseline.

6.12.10.7 Limitations

Assessing health risks from environmental chemicals is always associated with uncertainty. Where there is uncertainty, conservative assumptions have been used to ensure that risks have not been underestimated (and in fact almost certainly overestimated). In the exposure assessment, uncertainty relate to the assumptions regarding the presence of VCs. Conservative assumptions were made to ensure any ecological receptors that might be present in the vicinity of the proposed Project site are provided sufficient protection.

In the toxicity assessment, uncertainty is associated with predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, which is why there is some uncertainty associated with TRVs. In most cases, TRVs are assumed to be conservative (i.e., no toxicity is anticipated if site concentrations are below TRVs). This is because most reference values are based on the most sensitive species tested or a similar low effect level (e.g., 10^{th} or 25^{th} percentile of species sensitivity distribution), and toxicity tests upon which they are based are typically conducted under conditions that maximise toxicity (i.e., the use of soluble metal salts).

For risk characterisation, the ERs generated in the risk characterisation phase of the ERA should be considered to be conservative. ERs greater than 1 do not necessarily mean toxicity is occurring. There is greater inherent uncertainty associated with results of screening level assessments than higher-tier assessments, because results are based primarily on modelled or estimated concentrations and TRVs derived from literature studies, rather than direct measurements of exposure and effects. At the proposed Project site, no direct measurements of exposure were made and no toxicity studies were performed. In many cases, toxicity at a site is considerably diminished compared to effects predicted from laboratory studies, for a variety of reasons. Higher-tier assessments (i.e., Preliminary Quantitative ERA) incorporate site-specific toxicity data in a lines-of-evidence approach, which can reduce the level of uncertainty in this phase of the assessment.

6.12.10.8 Conclusion

Quantitative estimates of risk have been calculated using a quotient approach in which exposure estimates based on 95^{th} percentile concentrations have been compared to TRVs derived for each receptor / pathway. ERs greater than 1 are found for aquatic plants exposed to arsenic, cadmium, copper, molybdenum, nickel, and zinc via direct contact with surface water while ERs for all remaining COPCs are below 1 (Table 6.12.9-5).

Risk estimates for the proposed Project differ from the baseline. For aquatic plants, ERs for certain COPCs are higher in the effects assessment when compared to the baseline. Proposed Project effects surface water data (i.e., construction, operations, closure and post-closure) used in the ERA may have contributed in the change in ERs from the baseline assessment to the effects assessment.