APPENDIX I
BASELINE ECOLOGICAL RISK ASSESSMENT

Van Stone Mine Site
Baseline Ecological Risk Assessment

Prepared for:

Hart Crowser, Inc.

1700 Westlake Avenue North, Suite 200

Seattle, Washington 98109

Prepared by:

TerraGraphics Environmental Engineering, Inc.

121 S. Jackson St.

Moscow, ID 83843

TerraGraphics
Environmental Engineering, Inc.

www.terragraphics.com

and

Pascoe Environmental Consulting

210 Taylor Street, Rm 15

Port Townsend, WA 98368

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Acronyms and Abbreviations

AOI	Area of Interest
bw	body weight
CEEM	Conceptual Ecological Exposure Model
COEC	Contaminant of Ecological Concern
COPEC	Contaminant of Potential Ecological Concern
Ecology	Washington State Department of Ecology
Eco-SSL	Eco-Soil Screening Level
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
FS	Feasibility Study
HHRA	Human Health Risk Assessment
HQ	hazard quotient
LOAEL	low-observed-adverse-effects level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MTCA	Model Toxics Control Act
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects level
ODEQ	Oregon Department of Environmental Quality
QA	quality assurance
RI	Remedial Investigation
ROC	receptor of concern
TEE	Terrestrial Environmental Evaluation
TRV	toxicity reference value
UCL	upper confidence limit
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WQS	water quality standards

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Section 1.0 Introduction

This Baseline Ecological Risk Assessment (ERA) has been prepared for the Van Stone Mine in Stevens County, Washington (or "the Site") in accordance with the Washington State Model Toxics Control Act (MTCA; Washington Administrative Code [WAC] 173-340) (Ecology 2007). The purpose of this ERA is to assess potential hazards to ecological receptors from exposure to mine waste and contaminated media at the Site. Section 2.0 below describes the ecological characteristics of the Site, which form a primary basis for determining a conceptual ecological exposure model and the specific methodologies to evaluate ecological risks. Based on those characteristics, the first step in the ERA process involves screening the full data set of chemical contaminant concentrations in soils, surface waters, and sediments in order to select a list of Contaminants of Potential Ecological Concern (COPECs). For this ERA, the COPECs were selected for each environmental medium within each of the five exposure units, or Areas of Interest (AOIs), depicted in Figure 3 of the Remedial Investigation (RI; Hart Crowser 2013). Following the screening process, the approaches and specific methods for evaluating risks to both terrestrial and aquatic organisms at the Site are developed, following MTCA guidance. Results of the ERA and selection of Contaminants of Ecological Concern (COECs) are presented in Section 9.0 Ecological Risk Characterization, which includes discussion of uncertainties in the exposure and risk estimates. Uncertainty analyses, conclusions, summaries of site risks, and further recommendations are presented in Sections 10.0 through 13.0

Section 2.0 Ecological Characteristics of the Van Stone Mine Site

The Site is located in the upper Onion Creek watershed, a montane habitat characteristic of those in northeastern Washington. According to the Land Status Map in the closure plan report, U.S. Forest Service property is located on the south boundary of the Site property. Conifer forests and associated wildlife characterize the general region in which the Site is located.

A comprehensive analysis of the entire Onion Creek watershed titled *Onion Creek Watershed Analysis* was carried out in March 1997 for Boise Cascade Corporation by a number of organizations, including the Washington Department of Natural Resources, Washington Department of Ecology (Ecology), Stevens County Conservation District, Vaagen Brothers Lumber, Arden Tree Farm, Inland Empire Paper, Maurice Williamson, and the Washington Farm Forestry (Boise Cascade 1997). As per the watershed analysis, approximately 52 percent of the Onion Creek watershed is devoted to forestry. Other land uses include agriculture, small scale ranching, rural residential, open pit quarries, based metal mining (Van Stone lead-zinc operations), and several minor mineral claims. Riparian vegetation consists of small to medium mixed conifer stands ranging from sparse to dense growths. Canopy closure generally ranges from 90 percent to 100 percent. Deciduous species include trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera var. commutate*), and sitka alder (*Alunus sinuate*).

Forests in the immediate operations area include interior Douglas-fir (*Pseudotsuga menziesii var. glauca*), grand fir (*Abies grandis*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta var. latifolia*), and Engelmann spruce (*Picea engelmannii*). The tailings facility is surrounded by lodgepole pine, interior Douglas-fir, grand fir, and some western larch. Forest cover in the area of the mine site consists of a mixed deciduous-coniferous cover, composed of trembling aspen, paper birch, lodgepole pine, interior Douglas-fir, and western red-cedar (*Thuja plicato*).

Onion Creek has been categorized by Ecology as a Class AA (extraordinary) surface water body. Although there is a 100-foot-high series of falls 1.2 miles upstream from the mouth of Onion Creek, brook trout (*SalveIinus fontinalis*), and rainbow trout (*Oncorhynchus mykiss*) are found throughout the watershed (Boise Cascade 1997). The falls near the mouth of Onion Creek form a migration barrier to fish entering the upper portion of the watershed from the Columbia River. Salmonid species that have been observed in the past in small numbers in the lower mile of Onion Creek below the falls include adfluvial kokanee (*Oncorhynchus nerka*), bull trout (*Salvelinus confluentus*), and cutthroat trout (*Oncorhynchus clarkii*). Bull trout do not occur above the falls (Boise Cascade 1997).

Other than the falls upstream from the mouth of Onion Creek, there are no physical barriers to fish migration. Brook trout and rainbow trout utilize the entire network of tributaries above the falls throughout all life stages and do not segregate into specific areas. There are two potential road barriers (culverts) on the Northeast Fork of Onion Creek, one at the main Onion Creek road and one at a logging road crossing. However, neither of these precludes fish from moving into the mine site area. The Northeast Fork of Onion Creek in the mine site area is categorized as a confirmed fish-bearing Type 3 Stream for the majority of its length, although fish presence has not been confirmed in the upper reaches of each tributary (Boise Cascade 1997).

The Van Stone operations area provides habitat for a range of wildlife including white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus hemionus*), and black bear (*Ursus americanus*). The watershed report (Boise Cascade 1997) notes occasional reports of coyote (*Canis latrans*) and cougar (*Felix concolor*) in the area. Although there have been no detailed wildlife investigations of the mine site, it is expected that the area hosts a rather large spectrum of small mammals including bats (*Chiroptera*), mice, shrew, squirrels, chipmunks, gophers, voles, snowshoe hare (*Lagamorpha*), and members of the weasel family (*Mustelidae*).

Although there is very little standing or open water or wetland habitat in the area, the Van Stone property provides habitat for a large number of passerines, some waterfowl, upland game birds such as grouse, owls, and representatives of the raptor family (hawks, eagles). Many of the species that frequent the area are migratory or transitory.

Section 3.0 Selection of Chemicals of Potential Ecological Concern

This section describes how the analytical data are compiled and used to select COPECs. COPECs are chemicals that are present in the environment at levels that may place exposed ecological receptors at risk for experiencing adverse health effects that may partially or wholly originate from site-related sources.

3.1 Data Evaluation

Similar to the first step in the Human Health Risk Assessment (HHRA; TerraGraphics and Pascoe 2013), analytical results collected during the RI were reviewed to ensure suitability for use in the ERA. The ERA uses background and chemical data from samples of the following environmental media collected during the RI:

- Waste rock and tailings piles
- Surface and subsurface soils
- Surface water from Onion Creek and its tributaries
- Sediment from Onion Creek and its tributaries

Data quality was evaluated as part of the RI and qualifiers were assigned by the laboratory or the validator. Estimated values ("J") were used in the risk assessment. There were no rejected values ("R") deemed unusable for risk assessment purposes. When both an original sample and a field quality assurance (QA) sample were collected from the same sample location, the higher of the two results was used. All RI sample results collected from the Site in 2011 and 2012 were used to conduct the initial screening.

3.2 Screening Process

To identify COPECs at the Site, a stepwise selection process was used as described in WAC 173-340-7493 for the terrestrial evaluation, and also used for the aquatic habitats at the Site, consistent with U.S. Environmental Protection Agency (USEPA) guidance for ERA (USEPA 1997). Contaminants that did not meet any one of these screening steps were assumed to present negligible risks to ecological receptors and were screened out of the risk assessment process. The screening process consisted of three steps: (1) comparing Site chemistry data to background concentrations, (2) screening for frequency of detection, and (3) screening for potential ecological risks to select COPECs. Specifics of the screening process are described below; results are presented in Section 3.3.

- ***Comparison to Site Background Concentrations:*** Some chemicals have a wide range of occurrence in soil and water. Detecting these chemicals at the Site does not necessarily indicate that they were introduced by site releases. As per Table 749-3, footnote "a," WAC 173-340-7493, Site-specific background concentrations were included in the screening process. Where the ecological indicator concentrations were below background concentrations developed for the Site, the background concentrations served as the screening criteria. Site-specific background concentrations were developed in the RI as 90th percentiles of the background concentration data (Hart Crowser 2013). Contaminants with maximum concentrations in soil or sediment less than their site-specific background values were eliminated from further risk evaluation. Most background surface water results were below detection limits, so it was not possible to calculate 90th percentiles for surface water; therefore, contaminants in surface water were not screened against background.
- ***Frequency of Detection:*** The frequency of detection of each contaminant in each environmental medium was quantified, with the intention that contaminants which were detected in less than five percent of the samples would be eliminated from further evaluation. For soils, no contaminants were eliminated because all were detected in at least five percent of samples. Similarly for sediments, no contaminants were eliminated from further evaluation based on detection frequency.

- ***Screening for Potential Ecological Risks:*** In addition to screening of data against Site-specific background concentrations, maximum concentrations were screened against ecological risk-based criteria.
  - For soil, maximum concentrations in each AOI were screened against MTCA Terrestrial Environmental Evaluation (TEE) indicator soil concentrations provided in Table 749-3 of WAC 173-340-7490.
  - For sediments, maximum concentrations in each AOI were preferentially screened against criteria for freshwater sediments developed by the U.S. Geological Survey (USGS) in Ingersoll et al. (2000). Freshwater sediment criteria developed under MTCA (Ecology 2011a) were in draft form at the time this risk assessment was prepared and were used only for beryllium, selenium, and silver, for which USGS criteria are not available. For antimony and thallium, for which values were not available in Ingersoll et al. (2000) or as draft MTCA criteria, sediment screening criteria were taken from the sediment tabulation in National Oceanic and Atmospheric Administration (NOAA, 2012) and the lowest Tier II screening value from the Oregon Department of Environmental Quality (ODEQ, 2001), respectively. Ecological risk associated with sediments may be further evaluated during the feasibility study stage.
  - For surface waters, maximum concentrations in each AOI were preferentially screened against Washington State water quality standards for freshwater (Ecology 2003). For dissolved mercury and selenium, surface water screening criteria were concentrations in Section 304 of the Clean Water Act (USEPA 2006); for antimony, beryllium, and thallium, screening criteria were taken from NOAA (2012), and for silver, the screening criterion was the lowest Tier II screening value provided by ODEQ (2001).

  For all media, contaminants with maximum concentrations exceeding screening criteria constitute the COPECs for the ERA.

3.3 Results of COPEC Selection

Results of the comparisons of maximum concentrations of Site contaminants in individual AOIs with background and risk-based screening criteria are presented in the following tables: Soil data screening – Table 1, sediment data screening – Table 2, and surface water data screening – Table 3.

- ***Soil:*** 10 COPECs are identified for soil in AOI 1: antimony, arsenic, cadmium, copper, lead, mercury, nickel, silver, thallium, and zinc; six COPECs are identified for soil in AOIs 2, 3, and 4: arsenic, cadmium, copper, lead, mercury, and zinc; and zinc is identified as the single COPEC for AOI 5 (Table 1).
- ***Sediment:*** Zinc is identified as the only COPEC for sediment in AOI-5 Onion Creek and Tributaries (Table 2).
- ***Surface Water:*** Three COPECs are identified for surface water in AOI-1: cadmium, lead, and zinc; two COPECs are identified for AOI-2: lead and zinc; and one COPEC is identified for AOI-5: zinc (Table 3).

The COPECs selected for each environmental medium within individual AOIs are summarized in Table 4. The COPECs are further evaluated for ecological risks below for both terrestrial and aquatic habitats.

Section 4.0 Terrestrial Ecological Risk Assessment Approach

Risks to ecological receptors in the terrestrial habitats at the Site are evaluated following MTCA requirements for the TEE (Ecology 2007 and 2011b). The evaluation is based on environmental and waste characteristics of the Site. The approach to performing the TEE was determined through evaluation of existing site data and pertinent Ecology regulations in WAC 173-340-7490, as described in the following sections.

4.1 Scope of the TEE

MTCA (WAC 173-340-7490(2)) provides criteria for determining whether the Site can be excluded from a site-specific TEE, based on characteristics of the site. This first step of the TEE determines whether chemical contaminants at the Van Stone Site have the potential to pose a risk to wildlife or plants or affect the soil biota. Certain site circumstances provide an exclusion from any further ecological evaluation because the contaminants either have no pathway to harm the plants or animals (e.g., they are under buildings or deep in the ground), or there is no habitat where plants or animals live near the contamination, or finally, the contamination does not occur at concentrations higher than are found to occur naturally in the area.

The mine reclamation and closure plan report for the Van Stone Site (Beacon Hill Consultants 2002) provides a summary of site characteristics that impact whether a TEE can be excluded. The Site contains habitat where plants or animals can live near the contaminated soil, and the contamination appears to be elevated above concentrations naturally occurring in soils. In addition, the Site is located adjacent to U.S. Forest Service land on property that contains at least ten acres of native vegetation within 500 feet of the Site. Lastly, concentrations of contaminants in soil, surface water, and sediment of the Site are elevated above site-specific background levels, as shown above in the COPEC selection process. Based on these characteristics, in accordance with WAC 173-340-7491, the Site does not qualify for an exclusion from a TEE.

Whether the Site can undergo a simplified or site-specific TEE is determined by a scoring procedure in WAC 173-340-7492. Based on the acreage of high quality habitat, the Site does not qualify for a simplified TEE, and a site-specific TEE was performed.

4.2 Site-Specific TEE Method

The purpose of employing the site-specific TEE method is to ensure that the goals of the ecological evaluation are fulfilled: (1) Determining whether a release of hazardous substances to soil may pose a threat to the terrestrial environment, (2) characterizing existing or potential threats to terrestrial plants or animals exposed to hazardous substances in soil, and (3) establishing site-specific cleanup standards for the protection of terrestrial plants and animals (WAC 173-340-7489(1)(a)).

The site-specific TEE is intended to facilitate selection of a cleanup action by developing information needed to evaluate cleanup action alternatives in the Feasibility Study (FS). There are two elements in a site-specific ecological evaluation: (1) problem formulation, and (2) selection of methods to address issues identified during problem formulation.

Of the site-specific methods for TEE described in Ecology guidance, the method of comparison of exposure concentrations with ecological criteria under "Literature Survey" is used in this ERA (WAC 173-340-7493 (3)(a)). Other methods such as described under "Wildlife Exposure Model," "Soil Bioassays," or "Site-Specific Field Studies" were not utilized. In the Literature Survey site-specific method, the exposure point concentration (EPC) for each contaminant in soil is compared with a benchmark value to develop a Hazard Quotient (HQ) for the exposure of each receptor to each COPEC (WAC 173-340-7493 (4)(a)). An exceedance of the benchmark value by the exposure concentration (i.e., HQ >1.0) indicates possible unacceptable risk, and is discussed in light of uncertainties in assumptions in exposure estimates and toxicity information.

The approaches to performing the problem formulation step and the selection of the appropriate TEE methods at the Site are discussed in the following sections, after presentation of the aquatic risk assessment approach.

Section 5.0 Aquatic Risk Assessment Approach

The aquatic habitat at the Site is evaluated by comparing each concentration data point for each COPEC in surface water with Washington State water quality standards for protection of aquatic life, chronic criteria (WAC 173-201A; Ecology 2003), and in sediment with consensus freshwater sediment quality guidelines recommended by USGS (Ingersoll et al. 2000).

The methods for performing both the TEE and the aquatic risk assessment are described in the sections below. The following section on Problem Formulation provides the basis for evaluating ecological risks at the Site.

Section 6.0 Problem Formulation

As per guidance on conducting a TEE under MTCA, the scope of the ERA is defined through the problem formulation step (WAC 173-340-7493(2)), during which the physical characteristics (i.e., ecosystem components) of the Site are described. Both terrestrial and aquatic habitats are considered in this problem formulation. Ecosystem components include the important ecological habitats and aquatic and terrestrial plants and wildlife that use the habitats, including rare, threatened, and endangered species. This information is integrated into the Conceptual Ecological Exposure Model (CEEM), which presents the assessment communities and receptors of concern, ecological exposure media of concern, and exposure pathways to be assessed within the risk-based screening. Finally, assessment endpoints and measures are defined that describe the primary ecological concerns at the Site and link the risk-based screening results to risk management decisions. The CEEM and assessment and measurement endpoints are discussed further below.

6.1 Receptors of Concern

As part of the watershed report for the Site (Boise Cascade 1997), databases were searched for sensitive habitats or locations of special plants and animals. Results indicated that there are no known special plants or animals in the project area.

Based on the ecological characteristics of the Site, the dominant receptors of concern (ROCs) and their potential exposures at the Site consist of the following:

- Terrestrial plants exposed to COPECs in soil, waste rock, and tailings
- Terrestrial invertebrates exposed to COPECs in soil, waste rock, and tailings
- Terrestrial birds exposed to COPECs in soil, waste rock, tailings, surface water, and sediment
- Terrestrial mammals exposed to COPECs in soil, waste rock, tailings, surface water, and sediment
- Aquatic life exposed to COPECs in surface water and sediment
- Benthic (sediment-dwelling) invertebrates exposed to COPECs in sediment and surface water
- Piscivorous wildlife exposed via the food chain to COPECs in sediment

The benchmark values described below have been developed by various sources including Ecology to represent each of the above ROCs and their respective exposure pathways. The benchmark values are developed for the most sensitive species that represent each of the above ROC types, or for the ROC community. For example, for terrestrial birds, Ecology and others have developed benchmark values that represent the robin as the default sensitive indicator species, and similarly, benchmark values are available for the shrew as the sensitive representative of terrestrial mammals. Communities are represented by terrestrial plants, soil invertebrates, aquatic organisms, and benthic invertebrates.

6.2 Conceptual Ecological Exposure Model

The ROCs and their exposure pathways that are characteristic of the Site are integrated into the CEEM (Figure 1), which presents the assessment communities and ROCs, ecological exposure media of concern, sources of contamination, and the exposure pathways to be assessed within the risk-based screening.

- Plants and soil invertebrates are assumed to be exposed to contaminants in soils, regardless of habitat quality.
- Terrestrial wildlife ROCs are assumed to be exposed to contaminants through ingestion and contact with soils, including waste rocks and tailing piles.
- Aquatic and wildlife ROCs are assumed to be exposed to contaminants in surface waters and sediments of Onion Creek and to surface waters in water bodies located on the Site.

Within several AOIs at the Site, soil samples represent several soil types, including tailings piles, waste rock, and contaminated soils. The tailings piles and waste rock soils that are highly degraded may not provide quality food sources for wildlife. Nonetheless, the exposure pathways for these soils are considered to be complete for all ecological receptors, and exposures to soils are evaluated using the full soil dataset for each AOI. Uncertainties regarding ecological risks at the site are discussed in the Uncertainty Analysis in Section 10.0.

The ROCs and exposure pathways are integrated into the CEEM for the Site in Figure 1. The CEEM identifies the ecological ROCs, their exposure pathways, and exposure media at the Site.

6.3 Assessment and Measurement Endpoints

Assessment endpoints are descriptions of the environmental characteristics of concern at the Site (USEPA 1998) and generally represent ecological aspects that should be assessed in order to assure protection of the environment and allow informed site-specific risk management decisions. For the Van Stone ERA, assessment endpoints consist of protecting the survival and reproduction of species and communities. The ROCs selected above are representatives of the various feeding guilds present at the Site. These feeding guilds in turn represent the species and communities of wildlife organisms that may inhabit or use the Site, for which the assessment endpoints of protecting survival and reproduction are considered.

Measurement endpoints are the means for measuring the survival and reproduction assessment endpoints. For the ROCs and pathways identified in the CEEM and to meet the above assessment endpoints, the measurement endpoints are identified as the EPCs developed for each ROC and medium, which measure potential exposures of the ROCs. The benchmark values are risk-based or toxicity-based concentrations in environmental media to which the ROCs are exposed. The benchmark values are described in Section 7.0 below, and the EPCs are presented in Section 8.0.

Section 7.0 Benchmark Values

For the Literature Survey method under the site-specific TEE (WAC 173-340-7493(4)), benchmark values identified from the literature or from Ecology are developed for use in estimating risks. The following sources were used to identify benchmark values for comparison with the EPCs in the respective environmental medium.

7.1 Soil, tailings, and waste rock soil

Benchmark values for soil are identified for the protection of plants, soil invertebrates, and avian and mammalian wildlife. MTCA guidelines for the site-specific TEE (WAC 173-340-7493(4)(a)) identify benchmark values based on the following: "…soil concentrations established from a literature survey shall represent the lowest relevant LOAEL found in the literature." Benchmark values based on both no-observed-adverse-effects levels (NOAELs) and low-observed-adverse-effect levels (LOAELs) are used in this ERA (Table 5). The Eco-Soil Screening Level (Eco-SSL) values (USEPA 2012a) are based on compilations of NOAELs from multiple toxicity studies of soil contaminants. Where Eco-SSL values are unavailable, Oak Ridge National Laboratory values are used, followed by Tier II screening values in ODEQ

(2001), in a tiered approach. Where benchmark values are below the Van Stone site-specific background value, the background value is used in place of the benchmark value.

The primary benchmark values for soils are the Eco-SSLs because they are toxicity-based and designed by USEPA for estimating the potential for risks to ecological receptors from soil exposures. Limitations of the Eco-SSLs and the other benchmark values are that they are not site-specific because they are based on laboratory exposures, and for some values on species not necessarily present at the Site.

USEPA (2005) uses NOAEL-based toxicity reference values (TRVs) to derive Eco-SSLs, which are generally the geometric mean of NOAELs that were considered acceptable for use in Eco-SSL derivation. For some metals, USEPA (2005) uses the lowest NOAEL that has a bounded LOAEL from a single study, when that LOAEL is below the geometric mean NOAEL values. However, USEPA (2005) does not calculate Eco-SSLs based on LOAEL TRVs. The Eco-SSL database provides the LOAEL value that accompanies each NOAEL value that was used to derive the respective Eco-SSL. In order to develop LOAEL-based benchmark values for use in the ERA for the Van Stone site, the LOAEL TRVs in the Eco-SSL database were compared with the NOAEL TRVs for each COPEC, and a multiplication factor was derived to relate an appropriate LOAEL TRV to the NOAEL TRV that used for the Eco-SSL. This comparison was taken from an ERA work plan produced for California EPA review (Arcadis 2007). Based on this comparison, the work plan derived the LOAEL TRVs for each metal contaminant as factors of 10-fold or less of the NOAEL TRVs. Because USEPA's derivation of the NOAEL-based Eco-SSL follows a linear food chain method, keeping all other input factors unchanged, the NOAEL-based Eco-SSL can be multiplied by the LOAEL factor to arrive at a LOAEL-based screening level. Thus, for this ERA, each NOAEL-based Eco-SSL was multiplied by the factor derived from the Eco-SSL database to arrive at a LOAEL-based soil benchmark value. In the absence of established LOAEL-based Eco-SSLs, typically NOAELs would be factored by 10-fold to arrive at estimated LOAELs. Because the LOAEL TRVs in the Eco-SSL database range between slightly greater than 1 to 10 times the NOAEL TRVs, use of the Eco-SSL database to derive LOAEL-based benchmarks is more conservative than simply applying a factor of 10 across all NOAELs.

- Antimony – Avian benchmark values are not available. Small mammal LOAEL-based benchmark value is calculated at 10x NOAEL-based Eco-SSL. The LOAEL TRV of 0.59 milligrams per kilogram (mg/kg)-body weight (bw)/day is 10x NOAEL TRV of 0.059 mg/kg-bw/day, both values are from the same study recommended by USEPA (2005). However, the site-specific background value is used instead of the mammalian NOAEL benchmark value because the benchmark value is below background.
- Arsenic – Avian LOAEL-based benchmark value is calculated at 1.6x NOAEL-based Eco-SSL. The lowest bounded LOAEL TRV (3.55 mg/kg-bw/day) was 1.6 times greater than the selected NOAEL TRV used for the Eco-SSL (2.24 mg/kg-bw/day). Small mammal LOAEL-based benchmark value is calculated at 1.6x NOAEL-based Eco-SSL. The LOAEL TRV of 1.66 mg/kg-bw/day was from the same study as the NOAEL TRV of 1.04 mg/kg-bw/day selected by USEPA for the Eco-SSL.
- Cadmium – Avian LOAEL-based benchmark value is calculated at 4.3x NOAEL-based Eco-SSL. A LOAEL TRV of 6.35 mg/kg bw/day was derived as the geometric mean of

LOAEL values for the same endpoints as the NOAEL TRV of 1.47 mg/kg-bw/day (USEPA 2005). Small mammal LOAEL-based benchmark value is calculated at 10x NOAEL-based Eco-SSL. The LOAEL TRV of 7.7 mg/kg-bw/day is the bounded value from the same study as the NOAEL TRV of 0.77 mg/kg-bw/day that was used to derive the Eco-SSL (USEPA 2005). However, the site-specific background value is used instead of the mammalian NOAEL-based Eco-SSL because the Eco-SSL is below background.

- Copper – Avian LOAEL-based benchmark value is calculated at 3x NOAEL-based Eco-SSL. The LOAEL TRV of 12.1 mg/kg bw/day was the bounded value from the same study as the NOAEL TRV of 4.05 mg/kg-bw/day used to derive the Eco-SSL (USEPA 2005). Small mammal LOAEL-based benchmark value is calculated at 1.7x NOAEL-based Eco-SSL. The LOAEL TRV of 9.34 mg/kg-bw/day is the bounded value from the same study as the NOAEL TRV of 5.6 mg/kg-bw/day used to derive the Eco-SSL (USEPA 2005).
- Lead - Avian LOAEL-based benchmark value is calculated at 2x NOAEL-based Eco-SSL; the site-specific background value is used in place of the NOAEL-based Eco-SSL. The LOAEL TRV of 3.26 mg/kg-bw/day was the bounded value from the same study as the NOAEL TRV of 1.63 mg/kg-bw/day used to derive the Eco-SSL (USEPA, 2005). The background value was also used instead of the LOAEL-based benchmark value since it was less than background. Small mammal LOAEL-based benchmark value is calculated at 1.9x NOAEL-based Eco-SSL. The LOAEL TRV of 8.9 mg/kg-bw/day was the bounded value from the same study as the NOAEL TRV of 4.7 mg/kg-bw/day used to derive the Eco-SSL (USEPA 2005).
- Mercury – No avian or small mammal Eco-SSLs are available; the TEE wildlife value is used as the NOAEL-based benchmark value.
- Zinc – The NOAEL-based Eco-SSLs and LOAEL-based benchmark values are below the site-specific background concentration, which is used in place of the NOAEL-based and LOAEL-based values.

7.2 Sediment

As per Ecology recommendations, the consensus-based freshwater sediment quality guidelines developed by the USGS in Ingersoll et al. (2000) were used as sediment benchmark values; the consensus-based freshwater sediment quality guideline for zinc is 459 mg/kg.

7.3 Surface water

Washington State water quality standards (WQS) for freshwater organisms (Ecology 2003) are used as the primary source of surface water benchmarks for surface water exposures. The WQS used based on the default hardness of 100 mg/L $CaCO_3$ are 1.03 µg/L for cadmium, 2.52 µg/L for lead, and 105 µg/L for zinc. The actual median site background water hardness was 98 mg/L, which results in a negligible decrease in the WQS (1.02 µg/L for cadmium, 2.46 µg/L for lead, and 103µg/L for zinc) and does not alter the conclusions.

Section 8.0 Exposure Assessment

Ecological EPCs for each COPEC were developed for each environmental medium in each AOI to quantify exposures to ecological receptors that may use the Site. As per guidance in WAC 173-340-7493(2)(a)(i) for performing a site-specific TEE, the EPCs for soil were set at the 95 percent upper confidence limit (UCL) on the mean concentration of each constituent at each AOI. All 95 percent UCLs for contaminant data were determined using USEPA ProUCL software, and the 95 percent UCL value was taken as the recommended value, including when the 97.5 percent UCL was recommended. As per USEPA guidance on using ProUCL software (USEPA 2010), where the data set consisted of fewer than six detections, the maximum concentration is identified as the EPC; no soil contaminants were detected at fewer than six sample locations. Resultant 95 percent UCL EPCs for soil are shown in Tables 6 through 9 for AOIs 1 through 4.

Exposures to surface water and sediment samples are evaluated using individual sample concentrations, as well as 95 percent UCLs for when at least six detected samples were found. Fewer than six detections were found for all COPECs in surface waters of both AOI1 Mill Facility Open Pits and Waste Rock and AOI2 Upper Tailings Pile, and hence the evaluation uses concentration data from individual samples. Greater than six detections were found for the COPEC zinc in surface water at AOI5 (Onion Creek), and both individual samples and the 95 UCL on the mean of zinc concentrations are evaluated. For sediment, the only COPEC is zinc at AOI5 (Onion Creek), which was detected in all 22 samples; both individual samples and the 95 UCL on the mean of zinc concentrations are evaluated.

Section 9.0 Ecological Risk Characterization

Risk characterization presents the predicted ecological risks and discusses associated uncertainties. HQs are presented for plants, soil invertebrates, and wildlife as ROCs for the Site. Initial HQs are based on the combined data for each AOI and are presented for ranges of benchmark values. For those AOIs with soil samples representing a mix of non-vegetated and vegetated soils, data from all soil samples are combined for evaluating risks. The risk characterization describes why particular COECs are selected in order to focus any further assessment or remediation on those contaminants of most concern at the Site.

Risks for exposures to soils are estimated for the following ranges of benchmark values:

- Using EPCs derived as 95 percent UCLs and comparison with NOAEL-based Eco-SSLs, or similar NOAEL-based values where Eco-SSLs are unavailable.
- Comparison of EPCs with LOAEL-based benchmark values.

Risks to surface waters and sediments are evaluated using surface water and sediment quality criteria applied to both individual sample data points and 95 percent UCLs.

As mentioned above in Section 4.2, under MTCA, an exceedance of the ecological benchmark value by the exposure concentration (i.e., HQ >1) indicates possible unacceptable risk. A contaminant with a NOAEL-based HQ>1 for plants or invertebrates, or with a LOAEL-based HQ>1 for avian or mammalian wildlife is identified as a COEC. As a means of focusing the assessment on those COECs that pose the highest risk at each AOI, indicator hazardous substances are identified when either the HQ for plants or invertebrates or the LOAEL-based HQ for birds or mammals is greater than 5. This focus is intended to assist the management of risk by identifying those contaminants that pose the larger percentage of overall risk under the site-specific ecological risk assessment, as per MTCA suggestions (WAC 173-340-703).

9.1 Terrestrial Habitat

9.1.1 AOI1 – Mill Area

HQs for the combined soil samples representing the terrestrial habitat in AOI1 at the Van Stone Site are calculated with the following:

- **NOAEL-based Eco-SSLs –** Terrestrial plants, soil biota, and wildlife using NOAEL-based Eco-SSL in Table 10. Highest HQs were found for antimony, cadmium, lead, and zinc for birds and small mammals. For plants, lead and zinc have HQs greater than 5, and for invertebrates zinc has an HQ greater than 5.
- **LOAEL-based benchmark values –** Wildlife exposures with LOAEL-based benchmark values in Table 10. For birds and small mammals, HQs greater than 5 were found for cadmium, lead, and zinc.

Selection of the COECs for the terrestrial habitat of AOI1 is summarized in Table 11:

- Cadmium is identified as an indicator hazardous substance COEC for birds and small mammals.
- Lead is identified as an indicator hazardous substance COEC for plants, birds, and small mammals.
- Zinc is identified as an indicator hazardous substance COEC for plants, invertebrates, birds, and small mammals.

9.1.2 AOI2 – Upper Tailings Pile Area

HQs for the combined soil samples representing the terrestrial habitat in AOI2 at the Van Stone Site are calculated with the following:

- **NOAEL-based Eco-SSLs –** Terrestrial plants, soil biota, and wildlife using NOAEL-based Eco-SSL in Table 12. Highest HQs were found for cadmium, lead, and zinc. For plants and invertebrates, the zinc HQ is greater than 5.
- **LOAEL-based benchmark values –** Wildlife exposures with LOAEL-based benchmark values in Table 12. For birds, HQs greater than 5 were found for lead and zinc; and for small mammals, the LOAEL-based HQ for zinc is greater than 5.

Selection of the COECs for the terrestrial habitat of AOI2 is summarized in Table 13:

- Lead is identified as an indicator hazardous substance COEC for birds.

- Zinc is identified as an indicator hazardous substance COEC for plants, invertebrates, birds, and small mammals.

9.1.3 AOI3 – Lower Tailings Pile Area

HQs for the combined soil samples representing the terrestrial habitat in AOI3 at the Van Stone Site are calculated with the following:

- **NOAEL-based Eco-SSLs –** Terrestrial plants, soil biota, and wildlife using NOAEL-based Eco-SSL in Table 14. Highest HQs were found for lead and zinc. For plants, lead and zinc HQs are greater than 5, and for invertebrates the zinc HQ is greater than 5.
- **LOAEL-based benchmark values –** Wildlife exposures with LOAEL-based benchmark values in Table 14. For both birds and mammals, HQs greater than 5 were found for lead and zinc.

Selection of the COECs for the terrestrial habitat of AOI3 is summarized in Table 15:

- Lead is identified as an indicator hazardous substance COEC for plants, birds, and small mammals.
- Zinc is identified as an indicator hazardous substance COEC for plants, invertebrates, birds, and small mammals.

9.1.4 AOI4 – Tailings Pipeline and Road Area

HQs for the combined soil samples representing the terrestrial habitat in AOI4 at the Van Stone Site are calculated with the following:

- **NOAEL-based Eco-SSLs –** Terrestrial plants, soil biota, and wildlife using NOAEL-based Eco-SSL in Table 16. Highest HQs were found for cadmium, lead, and zinc. For plants and invertebrates, the zinc HQ is greater than 5.
- **LOAEL-based benchmark values –** Wildlife exposures with LOAEL-based benchmark values in Table 16. For birds, LOAEL-based HQs greater than 5 were found for lead and zinc; for small mammals, LOAEL-based HQs are greater than 5 for zinc.

Selection of the COECs for the terrestrial habitat of AOI4 is summarized in Table 17:

- Lead is identified as an indicator hazardous substance COEC for birds
- Zinc is identified as an indicator hazardous substance COEC for plants, invertebrates, birds, and small mammals.

9.1.5 AOI5 – Onion Creek

A single soil sample was collected at BG-12-SS for AOI5, for which the concentration of zinc, at 460 mg/kg, exceeded all soil criteria and site-specific background levels (Table 1).

9.2 Aquatic Habitat

Sediments in AOI5 Onion Creek – Five sediment locations in Onion Creek were found to present potential risks to sediment organisms, based on exceedances of the consensus sediment quality guidelines for zinc (Table 18); no other metals were identified as COPECs for sediments. The sediment samples of highest risks clustered at Onion Creek sample locations 7, 8, 9, and 11 (see Figure 1). The 95 percent UCL of the mean for zinc in all Onion Creek sediment samples was calculated at 405 mg/kg and did not exceed the consensus sediment quality guideline (Table 18). Overall, Onion Creek sediments do not show a potential for risks to sediment organisms, except at one cluster of locations; zinc is considered a COEC for the cluster of locations 7, 8, 9, and 11 in Onion Creek sediments.

Surface waters of AOI1 and AOI2 – Potential risks to aquatic receptors were calculated for the following (Table 19):

- AOI1 – Cadmium, lead, and zinc concentrations in the single sample from South Pit Lake (1.4 µg/L, 9.4 µg/L, 720 µg/L) exceeded their respective WQS (1.03 µg/L, 2.52 µg/L, 105 µg/L) and are COECs for surface water at AOI1; exceedances were not found for the discharge and seepage surface water samples from North Pit Lake. Because of the magnitude of exceedances, lead and zinc are considered indicator hazardous substances for surface water in AOI1. Whether cadmium poses potential risks to aquatic receptors at AOI1 is highly uncertain because the exceedance of WQS was slight (1.4-fold) and based on a single sample.
- AOI2 – Lead and zinc concentrations in sample UT-SW-2 (tailings discharge to the tributary) (5.3 µg/L and 230 µg/L) and in sample UT-SW-3 (tributary downstream of the discharge) (3.1 µg/L and 120 µg/L) exceeded their respective WQS (2.52 µg/L and 105 µg/L); exceedances were not found in the upper tailings seep sample. Lead and zinc are considered COECs for surface water in AOI2.

Surface waters of AOI5 Onion Creek – two samples (OC-9-SW and OC-11-SW) out of 20 samples had zinc concentrations of 130 µg/L, which exceed the Washington WQS by a factor of 1.2 (Table 19). No other samples in Onion Creek exceeded WQS. The 95 UCL on the mean of the zinc data for Onion Creek surface water (56.9 µg/L) did not exceed the WQS. Because of the low level of exceedance of the zinc standard, no COECs are identified for surface waters of Onion Creek. Onion Creek surface water is not considered to present risks to aquatic receptors based on those findings.

Section 10.0 Uncertainty Analysis

As per MTCA guidance (WAC 173-340-7493(5)), uncertainties associated with the ERA process are presented and discussed with regard to the potential to result in over- or under-estimation of the actual ecological risks. Uncertainties are associated with exposure estimates and with the benchmark values used to estimate risks.

10.1 Detection Limits for Surface Water Samples

Many metals were not detected in surface water samples, and subsequently were not selected as COPECs. For silver and thallium, which were undetected in all surface water samples of AOI1, AOI2, and AOI5 (Onion Creek) and not selected as COPECs, the detection limits were above the lowest screening criteria. The thallium detection limits were more than 40-fold higher than the lowest screening criterion, whereas silver detection limits were only 1.25-fold higher (see Table

3). Whether actual concentrations of silver or thallium in these surface water samples may be above their screening criteria and may present risks to aquatic receptors is uncertain.

10.2 Exposure Point Concentrations

The soil EPCs calculated in this ERA are based on data that combine different ranges of contamination levels across different soil types, such as waste rock, tailings piles, stained soils, and nearby vegetated soils along the Transect stations.

It is highly uncertain whether aquatic ROCs are present and exposed to contaminants in surface waters of the south pit lake of AOI1 or the discharge of the tailings pile at AOI2.

10.3 Benchmark Values

For the identification of most COPECs in soil, the benchmark values were taken from the USEPA Eco-SSL database, which derives the Eco-SSLs through a review process of NOAEL TRVs that pass specific acceptance criteria. The Eco-SSLs are considered to be screening values, and hence inherent uncertainty exists whether risks to ecological ROCs at the Van Stone Site are apparent from the calculated HQs. The Eco-SSLs were not derived for Site conditions, particularly for the waste rock and tailings pile types of soil that are found at the Site; the lack of site-specificity is a source of uncertainty in their use in the risk estimates.

As per MTCA TEE guidance, LOAEL-based benchmark values were used for wildlife ROCs in the ERA. Since Eco-SSLs have been developed by USEPA only as NOAEL-based values, the LOAEL-based benchmark values were taken from a literature source that derived them from the Eco-SSL database. The use of these LOAEL-based benchmark values is also considered to have uncertainty for the ERA due to lack of site-specificity.

10.4 Bioavailability Considerations

A significant source of uncertainty at the Van Stone Site is whether the metals found in soils contaminated with hard rock mining wastes may have lower bioavailability than is assumed in the benchmark values used for estimating risks. As described above, the soil benchmark values used in this ERA are derived from Eco-SSLs (USEPA 2005), or are values developed in Oak Ridge Laboratory publications (Efroymson et al. 1997a, b) and in ODEQ (2001). As USEPA (2005) states, the Eco-SSL values for plants, soil biota, and wildlife were developed for upland soils, can be applied to wetland soils, and typical contamination sources in the base studies are discharges, leaks, spills, and aerial deposition to soils from smelter or other industrial discharges. Metals in soils from such releases are typically in the forms of dissolved metals bound to iron, or manganese oxides bound to organic material, or bound with sulfides (Salomons 1995).

In contrast, metals in soils contaminated primarily with hard rock mining wastes, rather than smelter or industrial discharges, are more typically fixed in a crystalline phase and have low bioavailability relative to the other forms in soil (USGS 1996). Because of this lower bioavailability, the exposure of ecological receptors to metals in mining waste soils, through direct exposure or through ingestion of food items, would also be lower than found with non-mining waste soils. This has been demonstrated in field studies with mining-waste-contaminated soils from sites in the northern Rocky Mountains (Davis et al. 1992, Pascoe et al. 1994). The

Eco-SSLs do not account for such reduced bioavailability and are developed with an assumption of 100 percent bioavailability of metals (USEPA 2005). In other words, the Eco-SSLs and equivalent values are not specific for soils contaminated with hard rock mining wastes, such as those found at the Van Stone Site, and may overestimate assumed exposures because of the lack of consideration for potentially reduced bioavailability. Similarly, the plant and biota benchmark values in the Oak Ridge Laboratory publications (Efroymson et al. 1997a, b) are based on toxicity tests using laboratory or contaminated industrial soils, not soils contaminated with waste metals due to hard rock mining where bioavailability would be expected to be lower.

Because of the reduced bioavailability of metals from mining waste soils compared to other soil types, adjustments could be made to the EPCs used in the TEE to account for reduced exposures. Use of such adjustments would assume that they reflect the reduced bioavailability of metals from mining waste soils at the Site compared with the bioavailability of metals from soils in the critical toxicity studies used in the development of benchmark values, such as the Eco-SSLs. Inclusion of adjustments for bioavailability in a TEE would be assumed to be consistent with the Literature Survey site-specific method (WAC 173-340-7493(3)(a)), which describes alternate methods that can be used for conducting a site-specific TEE, for the purposes of *"(ii) Identifying a soil concentration for the protection of plants or soil biota more relevant to site-specific conditions than the value listed in Table 749-3; (iii) Obtaining a value for any of the wildlife exposure model variables listed in Table 749-5 to calculate a soil concentration for the protection of wildlife more relevant to site-specific conditions than the values listed in Table 749-3."* Following this guidance, bioavailability factors would be specific to a comparison of bioavailability of metals contained in mining waste soils, characteristic of the Van Stone Site soils, with the bioavailability of metals from non-mining waste soils. The Literature Survey site-specific method in WAC 173-340-7493(4)(a) advises when including bioaccumulation factors in the food web model for developing TEEs for wildlife that*"(iii) The bioaccumulation factor value shall be as appropriate as possible for the receptor being assessed; (v) The literature benchmark value, toxicity reference value, or bioaccumulation factor should preferably correspond to the chemical form being assessed"*. The inclusion of a bioavailability factor as an adjustment to exposures would account for differences in the bioaccumulation of metals bound to different soil types.

Bioavailability factors to account for reduced exposures to metals in mining waste-contaminated soils are not readily available, and are not used in this TEE. USEPA Region 8 (2012b) advises that bioavailability for lead in mine rocks (galena) should range from 1 to 6 percent compared with about 10 percent for lead in other soils. Bioavailability factors that would account for the differential uptake of mining waste metals compared with metals from non-mining waste soils can be calculated from the uptake factors for plants, earthworms, and small mammals compiled by the Oak Ridge National Laboratory (Bechtel Jacobs 1998, Sample et al. 1998). Such bioavailability factors could be developed by comparison of uptake of metals into plants from soils contaminated by mine wastes (termed "field mine waste" in Bechtel Jacobs 1998) with that from soils supplemented with zinc and lead (as metal salts) in laboratory uptake studies. The latter soils would be consistent with the form of metal used in the laboratory toxicity tests used to derive Eco-SSLs and other soil benchmarks. The ratio of the uptake factors for the mine waste soils and the metal-salt-supplemented soils would be the bioavailability factor, sometimes called the relative bioavailability factor. Data on uptake of lead from mine waste soils and non-mining waste soils are available for plants and earthworms in Pascoe et al. (1994) and ETI (1993). For small mammals, Sample et al. (1998) provides uptake factors for numerous metals for field mining waste soils and non-mining waste soils that can be used to develop bioavailability factors.

Key uncertainties with this approach would be the availability of sufficient data to develop the bioavailability factors and the lack of specificity to the Van Stone Site. Inclusion of bioavailability factors developed from the above sources would be expected to decrease biota exposures to 20-50 percent for lead and zinc in mining-waste-impacted soils.

10.5 Reducing Uncertainty

Uncertainty in risk estimates can be reduced by filling potential data gaps that were not obvious prior to conducting the RI. Such information can include site-specific contaminant toxicity data and/or exposure information to better refine risks.

For soils, although risk estimates are high for exposures to waste rock or tailings piles, they are also uncertain because the waste rock and tailings piles provide relatively lesser quality habitat for plants and invertebrates and the general lack of food resources for wildlife. Higher quality habitat is located nearby and may provide some compensatory ecological services to the low quality degraded habitats. Any increase in habitat in presently non-vegetated areas would increase exposures and ecological risks. Although not specifically evaluated or tabulated in this ERA, potential risks to plants, invertebrates, and wildlife are likely, though uncertain, for higher quality habitats presently located near but not within the degraded areas of waste rock or tailing piles, due to elevated concentrations of lead and zinc. Reduction of those concentrations will reduce those risks. The estimation of risks specifically in the higher quality habitat areas would provide information on whether soils in those areas may need management to reduce risks to wildlife.

The risk estimates do not consider any reduced bioavailability of metals from mining waste soils to plants, soil invertebrates, and small mammals, relative to the bioavailability inherent in the studies used to derive the benchmark values. Reduced bioavailability of metals from the mining waste soils at the Van Stone Site is based on findings from other sites with hard rock mining wastes. Uncertainty in whether metals bioavailability may be reduced in waste rock compared with non-waste rock soils could be addressed though application of additional assessment tools such as soil bioassays, following WAC 173-340-7493(3)(b).

Additional analysis of soils by geographical sub-areas may be useful for future management decisions regarding the Site. For example, the stained soils area of AOI1 contained some of the highest metals concentrations. Those soils could provide future habitat for plants and soil biota along with food sources for wildlife. Evaluation of those soils could be useful for future management of AOI1.

For Onion Creek, additional assessment tools for evaluating surface water or sediment, such as toxicity tests or stream macroinvertebrate analyses, may not be necessary based on the low level of exceedances of both surface water criteria and sediment guidelines for zinc.

Section 11.0 Ecological Risk Assessment Conclusions

The results of the ERA are summarized in this section, and any recommendations for additional assessment of risk to ecological receptors are provided, as deemed necessary to understand the potential for risks that may result from exposure to COECs at the Site.

Based on a screening evaluation, numerous metals were identified as COPECs in soils of AOI1, AOI2, AOI3, and AOI4 at the Site. Cadmium, lead, and zinc were identified as COPECs for surface waters in AOI1; lead and zinc were identified as COPECs for surface water in AOI2; and zinc was identified as a COPEC for surface water and sediment in Onion Creek (AOI5). This site-specific ERA was performed using EPCs based on the 95 percent UCLs of the mean concentrations of metals in soils, individual sample concentration data for surface waters and sediments, and by using NOAEL-based Eco-SSLs, LOAEL-based benchmarks developed from the Eco-SSL study data, Washington WQS for surface water, and USGS-recommended guidelines for sediment.

The ERA found that lead and zinc in waste rock and tailings piles would pose a risk to plants and invertebrates that grow or reside in Site soils, particularly in AOI1 where concentrations are highest.

Surface waters of AOI1 and AOI2 were found to present risks to aquatic receptors at the south pit lake of AOI1 due to cadmium, lead, and zinc; and to receptors in the discharge of AOI2 Upper Tailings Pile, due to lead and zinc. It is highly uncertain whether aquatic ROCs are present and exposed to contaminants in these waters.

In surface waters of AOI5 (Onion Creek), a single sample out of 20 samples showed an exceedance of the Washington WQS for zinc by a factor of 1.2. No other samples in Onion Creek exceeded WQS. Because of the low level of exceedance of the zinc standard, no COECs are identified for surface waters of Onion Creek. Onion Creek surface water is not considered to present risks to aquatic receptors based on those findings.

Five sediment locations in Onion Creek were found to present potential risks to sediment organisms, based on exceedances of the consensus sediment quality guidelines for zinc; no other metals presented sediment risks. The sediment samples of highest risk were found at Onion Creek locations 7, 8, 9, and 11. The 95 percent UCL of the mean of all Onion Creek sediment samples for zinc did not exceed the guideline. Overall, Onion Creek sediments do not show a potential for risks to sediment organisms except at the above four locations; zinc is considered a COEC for those Onion Creek sediment locations.

Section 12.0 Summary of Site Ecological Risks

The ERA narrowed the focus to COPECs for ecological risks by screening for frequency of detection, and comparison of site-wide maximum contaminant concentrations with site-specific background levels and risk-based criteria. The ERA also identified numerous COPECs for potential risks to ecological receptors in soils, zinc in sediment of Onion Creek, and cadmium, lead, and zinc in surface water.

For this ERA, ecological receptors consisted of terrestrial plants, soil invertebrates, birds, and mammals. All receptors were assumed to be exposed to both vegetated and non-vegetated (i.e., waste rocks and tailings piles) areas of the Site.

EPCs were identified as the 95 percent UCLs of the mean concentrations (or maximum concentrations where data were insufficient) of each COPEC within each type of media in each AOI. For surface water and sediment exposures, individual sample concentrations were used as the EPCs. Ecological risks associated with exposures to soil, surface water, and sediment were calculated by comparison of the EPCs to LOAEL-based benchmark values, State WQS, and consensus-based criteria, respectively.

12.1 AOI1 – Mill Area

Cadmium, lead, and zinc pose potential risks to birds and small mammals at AOI1. Lead and zinc also pose risks to plants, and zinc poses a risk to soil invertebrates. Highest concentrations of COECs are found in stained soils at the mill area and in non-vegetated waste rock samples.

Surface waters of the south pit lake of AOI1 were found to present risks to aquatic receptors due to cadmium, lead, and zinc. Whether aquatic receptors may use or be present in the south pit lake is uncertain.

12.2 AOI2 – Upper Tailings Pile Area

Zinc poses risks to terrestrial plants, invertebrates, birds, and small mammals at AOI2 due to exceedances of benchmarks and site-specific background levels. Lead poses risks to birds.

Surface water discharging from the AOI2 Upper Tailings Pile was found to present risks to aquatic receptors due to lead and zinc. Whether aquatic receptors may be exposed to the discharge water is uncertain.

12.3 AOI3 – Lower Tailings Pile Area

Zinc poses risks to terrestrial plants, invertebrates, birds, and small mammals at AOI3 due to exceedances of benchmarks and site-specific background levels. Lead poses risks to plants, birds, and small mammals.

12.4 AOI4 – Tailings Pipeline and Road Area

Zinc poses risks to terrestrial plants, invertebrates, birds, and small mammals at AOI4 due to exceedances of benchmarks and site-specific background levels. Lead poses risks to birds.

12.5 AOI5 – Onion Creek

Surface waters of AOI5 do not pose a risk to aquatic receptors. For sediment, four locations in Onion Creek (locations 7, 8, 9, and 11) were found to present potential risks to sediment organisms due to zinc. Whether the levels of zinc in sediments at those locations have impacted the benthic macroinvertebrate communities under present conditions is unknown.

Section 13.0 Summary of Further Recommendations

Recommendations for further evaluation to refine the risk estimates consist of the following:

1) Address uncertainty in metals bioavailability through TEE assessment tools such as incorporation of literature bioavailability factors into exposure estimates and performance of soil bioassays.
2) Address uncertainty in risks associated with zinc in Onion Creek sediments through stream macroinvertebrate analyses.

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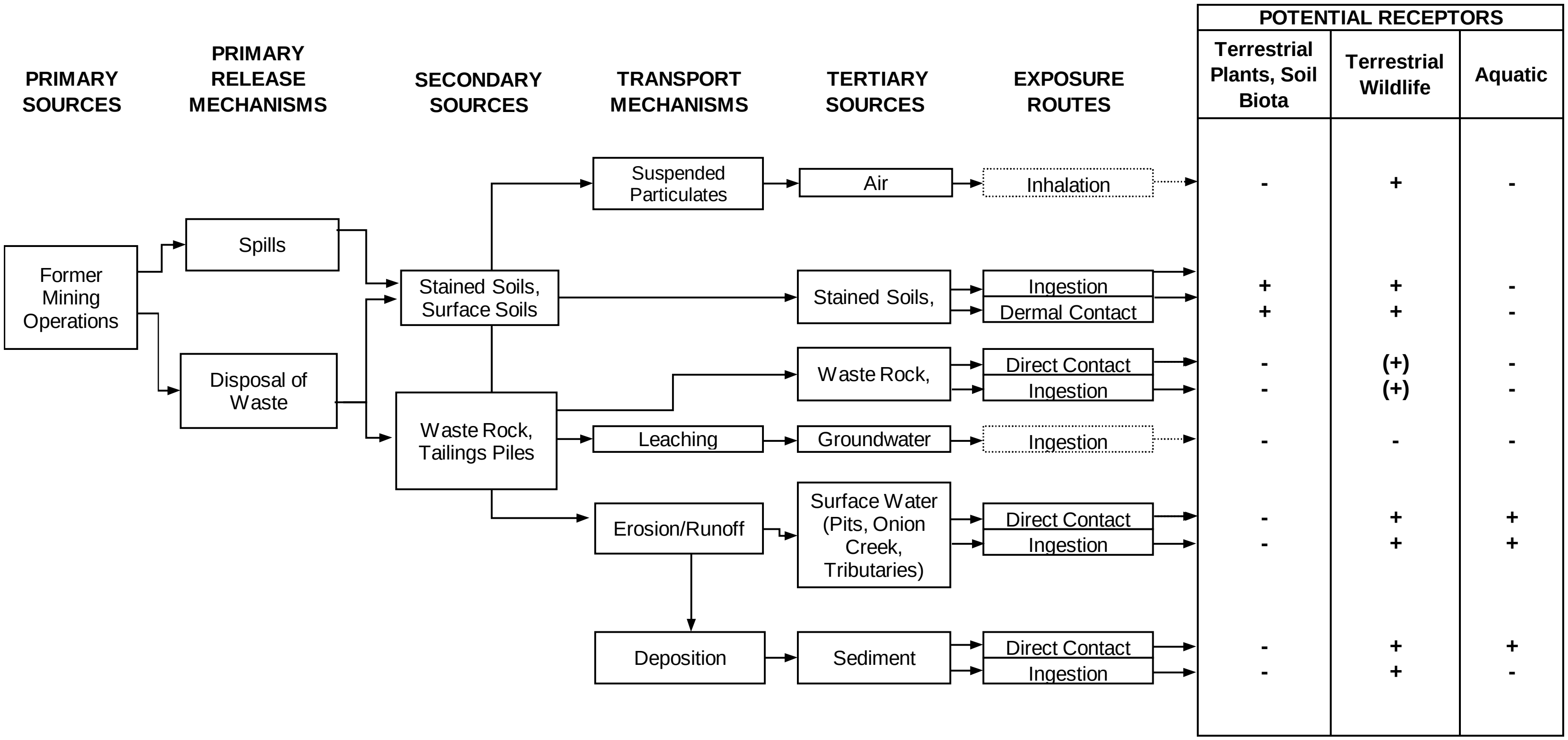
Figure 1. Conceptual Ecological Exposure Model for Van Stone Mine Site



Notes:

- **+** Complete and potentially significant exposure
- **-** Insignificant or incomplete exposure pathway or medium
- **(+)** Uncertain exposures

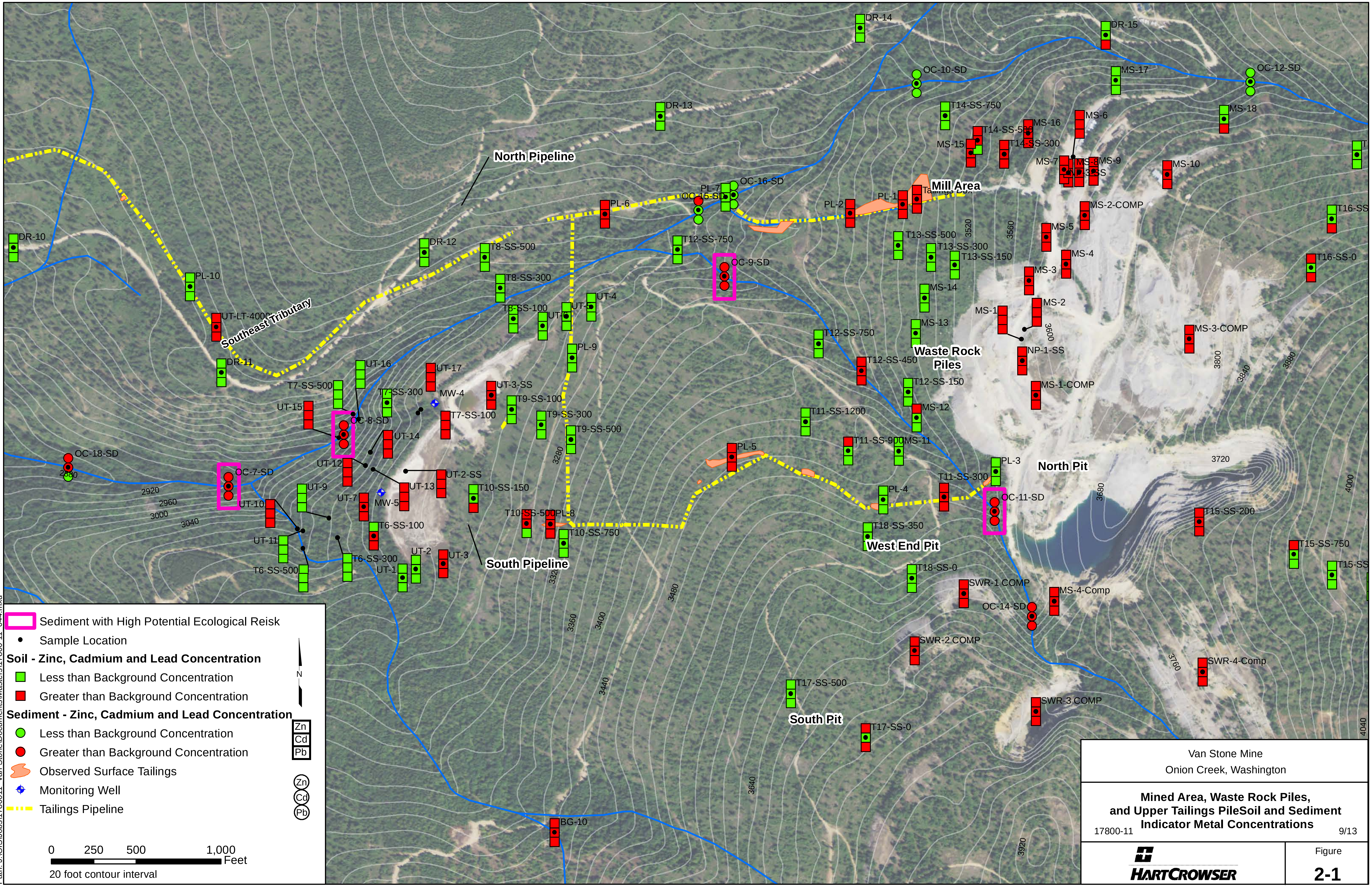


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Table 1. Results of Screening Soils

AOI	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
	Contaminant												
AOI-1: Mill Facility, Open Pits and Waste Rock													
Maximum Concentration (mg/kg):	**20**	**45**	1.2	**180**	35	**640**	**26000**	**2.8**	**45**	0.84	**3.6**	**1.3**	**37000**
Detection Frequency:	100%	100%	53%	100%	71%	73%	100%	98%	71%	86%	98%	57%	100%
COPEC?	**Yes**	**Yes**	No	**Yes**	No	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
AOI-2: Upper Tailings Pile													
Maximum Concentration (mg/kg):	3.1	**16**	1.9	**15**	8.6	**150**	**1200**	**0.2**	7.5	1	0.55	0.41	**6500**
Detection Frequency:	97%	100%	74%	100%	94%	88%	100%	100%	97%	55%	97%	35%	91%
COPEC?	No	**Yes**	No	**Yes**	No	**Yes**	**Yes**	**Yes**	No	No	No	No	**Yes**
AOI-3: Lower Tailings Pile													
Maximum Concentration (mg/kg):	5	**14**	1.7	**35**	9.3	**180**	**9500**	**0.21**	24	1.2	0.27	0.42	**11000**
Detection Frequency:	100%	100%	53%	100%	68%	79%	100%	100%	80%	85%	100%	30%	90%
COPEC?	No	**Yes**	No	**Yes**	No	**Yes**	**Yes**	**Yes**	No	No	No	No	**Yes**
AOI-4:Tailings Pipeline and Access Road													
Maximum Concentration (mg/kg):	5	**21**	0.72	**25**	10	**81**	**1000**	**0.45**	26	1.1	0.52	0.3	**7700**
Detection Frequency:	100%	100%	85%	100%	100%	100%	100%	82%	100%	91%	97%	45%	100%
COPEC?	No	**Yes**	No	**Yes**	No	**Yes**	**Yes**	**Yes**	No	No	No	No	**Yes**
AOI-5: Onion Creek and Tributaries													
Maximum Concentration (mg/kg):	0.19	3.3	0.46	1.5	7.8	3.6	46	0.045	5.9	0.66	0.066	0.17	**460**
COPEC?	No	No	No	No	No	No	No	No	No	No	No	No	**Yes**
TEE Soil Screening (Table 749-3)													
Plant (mg/kg)	5	10	10	4	42	100	50	0.3	30	1	2	1	86
Soil Biota (mg/kg)	-	60	-	20	42	50	500	0.1	200	70	-	-	200
Wildlife (mg/kg)	-	132	-	14	67	217	118	5.5	980	0.3	-	-	360
Lowest Indicator Concentration (mg/kg):	5	10	10	4	42	50	50	0.1	30	0.3	2	1	86
Site-specific background (mg/kg):	0.857	5.04	0.719	1.596	15.84	12.65	44.87	0.134	13.05	1.654	0.122	0.203	206
Highest of Indicator Conc. or Background (mg/kg):	**5**	**10**	**10**	**4**	**42**	**50**	**50**	**0.134**	**30**	**1.654**	**2**	**1**	**206**

Bold = Lowest Indicator Concentration or Background where Indicator Concentration is below background (mercury, selenium, and zinc).

Bold and Highlighted = Maximum concentration exceeds Indicator concentration or Background; identified as COPEC.

Background = 90th percentile of background sample data or 4x median, as per MTCA; taken from background memo (Hart Crowser 2012).

COPEC = Contaminant of Potential Ecological Concern.

Table 2. Results of Screening Sediments

AOI	Contaminant												
	Antimony	**Arsenic**	**Beryllium**	**Cadmium**	**Chromium**	**Copper**	**Lead**	**Mercury**	**Nickel**	**Selenium**	**Silver**	**Thallium**	**Zinc**
AOI5: Onion Creek and Tributaries													
Maximum Concentration (mg/kg):	1	7.8	0.44	4.5	7.3	8	110	0.13	6.4	0.82	0.068	0.26	**970**
Detection Frequency:	100%	100%	86%	95%	100%	95%	100%	95%	100%	73%	95%	14%	100%
COPC?	No	No	No	No	No	No	No	No	No	No	No	No	**Yes**
Sediment Screening (mg/kg)													
Ingersoll et al. (2000)		33		4.98	111	149	128	1.06	48.6				459
WA draft SQV (Ecology 2011)	(a)		0.46 (b)							11	0.57		
NOAA SQuiRT	3												
ODEQ Tier II												0.7 (c)	
Lowest Indicator Concentration (mg/kg):	3	33	0.46	4.98	111	149	128	1.06	48.6	11	0.57	0.7	459
Site-specific background (mg/kg):	0.587	6.662	0.741	0.427	14.33	12.2	22.8	0.0284	10.95	2.029	0.088	0.406	120.4
Highest of Indicator Concentration or Background (mg/kg):	**3**	**33**	**0.741**	**4.98**	**111**	**149**	**128**	**1.06**	**48.6**	**11**	**0.57**	**0.7**	**459**

Bold = Lowest of Screening Criteria, or Background where Screening Criteria are below background (beryllium).

Bold and Highlighted = Maximum concentration exceeds Screening Criterion or Background; identified as COPEC.

Background = 90th percentile of background sample data or 4x median, as per MTCA; taken from background memo (Hart Crowser 2012).

NOAA = Sediment Quality Table (SQUIRT) (http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf)

a. Value of 0.3 m/kg is "Not recommended for promulgation at this time", due to analytical uncertainties and high false positives in lab toxicity studies (Ecology 2011a).

b. Draft WA Sediment Quality Value (Avocet 2003); although not considered toxic in freshwater sediments according to Ecology (2011a)

c. Tier II screening level calculated by ODEQ (2001) to prevent bioaccumulation into piscivorous wildlife exposed to surface waters.

Table 3. Results of Screening Surface Waters

AOI	Antimony	Arsenic	Beryllium	**Cadmium**	Chromium	Copper	**Lead**	Dissolved Mercury	Total Mercury	Nickel	Selenium	Silver	Thallium	**Zinc**
	Contaminant													
AOI 1 - Mill Facility, Open Pits and Waste Rock														
Maximum Concentration (µg/L):	< 2	< 3.8	< 0.51	**1.4**	< 1.4	< 0.55	**9.4**	NA	NA	< 2	< 3.6	< 0.15	< 1.4	**720**
Detection Frequency:	0%	0%	0%	67%	0%	0%	33%	-	-	0%	0%	0%	0%	100%
COPC?	No	No	No	**Yes**	No	No	**Yes**	No	No	No	No	No	No	**Yes**
AOI-2: Upper Tailings Pile														
Maximum Concentration (µg/L):	< 0.4	< 3.8	< 0.51	0.63	1.5	10	**5.3**	< 0.0005	0.000889	3.9	< 3.6	< 0.15	< 1.4	**230**
Detection Frequency:	0%	0%	0%	67%	33%	100%	67%	0%	100%	33%	0%	0%	0%	100%
COPC?	No	No	No	No	No	No	**Yes**	No	No	No	No	No	No	**Yes**
AOI 5 - Onion Creek														
Maximum Concentration (µg/L):	13	< 3.8	< 0.51	0.31	< 1.4	1.4	0.66	0.000916	0.00115	< 2	< 3.6	< 0.15	< 1.4	**130**
Detection Frequency:	71%	0%	0%	10%	0%	10%	19%	43%	81%	0%	0%	0%	0%	81%
COPC?	No	No	No	No	No	No	No	No	No	No	No	No	No	**Yes**
Surface Water Criteria (dissolved)														
WA WQS chronic (µg/L)	-	190	-	1.03	178	11	2.52	-	0.012	157	-	-	-	105
Section 304 of CWA (µg/L)	-		-					0.77			5	-	-	
NOAA SQUIRT (µg/L)	30		0.66									0.36	0.03	
ODEQ Tier II Lowest (µg/L)	1000		5.3									0.12	40	
Lowest Surface Water Criterion (µg/L):	**30**	**190**	**0.66**	**1.03**	**178**	**11**	**2.52**	**0.77**	**0.012**	**157**	**5**	**0.12**	**0.03**	**105**

Bold = Lowest of Surface Water Criteria.

Bold and Highlighted = Maximum concentration exceeds lowest Surface Water Criterion; identified as COPEC.

NA = Not analyzed.

< = Not detected at the nominal detection limit; undetected concentrations with "U" qualifier are used at the detection limit (DL) value.

Table 4. Summary of Contaminants of Potential Ecological Concern (COPEC)

AOI	Soils	Surface Waters	Sediments
AOI-1: Mill Facility, Open Pits and Waste Rock	Antimony Arsenic Cadmium Copper Lead Mercury Nickel Silver Thallium Zinc	Cadmium Lead Zinc	NE
AOI-2: Upper Tailings Pile	Arsenic Cadmium Copper Lead Mercury Zinc	Lead Zinc	NE
AOI-3: Lower Tailings Pile	Arsenic Cadmium Copper Lead Mercury Zinc	NE	NE
AOI-4:Tailings Pipeline and Access Road	Arsenic Cadmium Copper Lead Mercury Zinc	NE	NE
AOI-5: Onion Creek and Tributaries	Zinc	Zinc	Zinc

NE = Not evaluated

Table 5. Soil Benchmark Values

	Benchmark Values (mg/kg)									
	Plants		Invertebrates		Wildlife					
					Avian			Mammlian		
COPEC	NOAEL-Based		NOAEL-Based		NOAEL-Based		LOAEL-Based [1]	NOAEL-Based		LOAEL-Based [1]
Antimony	5	(2)	78	(3)	NA	-	NA	0.857	(4)	2.7
Arsenic	18	(3)	60	(2)	43	(3)	68.8	46	(3)	73.6
Cadmium	32	(3)	140	(3)	0.77	(3)	3.31	1.596	(4)	3.6
Copper	70	(3)	80	(3)	28	(3)	84	49	(3)	83.3
Lead	120	(3)	1700	(3)	44.9	(4)	44.9	56	(3)	106.4
Mercury	0.3	(2)	0.134	(4)	5.5	(5)	NA	5.5	(5)	NA
Nickel	38	(3)	280	(3)	210	(3)	NA	130	(3)	NA
Silver	560	(3)	50	(6)	4.2	(3)	NA	14	(3)	NA
Thallium	1	(2)	NA	-	NA	-	NA	1	(2)	NA
Zinc	206	(4)	206	(4)	206	(4)	206	206	(4)	206

1. LOAEL-Based = LOAEL-based benchmark value, derived by adjusting the NOAEL-based EcoSSL (see text).
2. Oak Ridge National Laboratory (Efroymson et al. 1997a,b); values are LOAEL-based benchmark values since NOAEL benchmark values are not available, and are the same values as the MTCA plant TEEs for antimony, mercury, and thallium, and MTCA soil biota TEE for arsenic.
3. EcoSSL (USEPA 2005); Eco-SSLs are the geometric mean of NOAEL-based benchmark values (avian, mammalian) or maximally accepted toxic concentrations (plants, invertebrates).
4. Benchmark value was less than site-specific background, so site-specific background value is
5. TEE; WAC 173-340-7493, Table 749.3; Wildlife screening levels are the lowest of values calculated for avian and mammalian receptors.
6. Tier II screening level, Oregon Department of Environmental Quality (ODEQ 2001).
NA = not available or not calculated.

Table 6. EPCs - AOI1 Mill Facility, Open Pits and Waste Rock

COPEC	Maximum Concentration (mg/kg)	Area-wide EPC (mg/kg)	Basis of EPC[1]	Site-Specific Background (mg/kg)[2]
Antimony	20	7.3	97.5% KM (Chebyshev) UCL	0.857
Arsenic	45	10.5	95% H-UCL	5.04
Cadmium	180	41.0	95% Chebyshev (Mean, Sd) UCL	1.596
Copper	640	124	97.5% KM (Chebyshev) UCL	12.65
Lead	26000	7277	97.5% Chebyshev (Mean, Sd) UCL	44.87
Mercury	2.8	0.60	95% KM (Chebyshev) UCL	0.134
Nickel	45	8.52	95% KM (BCA) UCL	13.05
Silver	3.6	1.02	95% KM (Chebyshev) UCL	0.122
Thallium	1.3	0.37	95% KM (t) UCL	0.203
Zinc	37000	10144	95% Chebyshev (Mean, Sd) UCL	206

COPEC = Contaminant of potential ecological concern

EPC = Exposure point concentration

1. 95 UCL concentrations used as recommended from the ProUCL program (USEPA 2010).

2. Background is calculated as the 90th percentile value for each contaminant (Hart Crowser 2012)

Table 7. EPCs - AOI2 Upper Tailings Pile

COPEC	Maximum Concentration (mg/kg)	Area-wide EPC (mg/kg)	Basis of EPC[1]	Site-Specific Background (mg/kg)[2]
Arsenic	16	5.326	95% Approximate Gamma UCL	5.04
Cadmium	15	7.422	95% Chebyshev (Mean, Sd) UCL	1.596
Copper	150	45.1	97.5% KM (Chebyshev) UCL	12.65
Lead	1200	348.6	95% Chebyshev (Mean, Sd) UCL	44.87
Mercury	0.2	0.129	97.5% KM (Chebyshev) UCL	0.134
Zinc	6500	4116	99% KM (Chebyshev) UCL	206

COPEC = Contaminant of potential ecological concern

EPC = Exposure point concentration

1. 95 UCL concentrations used as recommended from the ProUCL program (USEPA 2010).
2. Background is calculated as the 90th percentile value for each contaminant (Hart Crowser 2012)

Table 8. EPCs - AOI3 Lower Tailings Pile

COPEC	Maximum Concentration (mg/kg)	Area-wide EPC (mg/kg)	Basis of EPC[1]	Site-Specific Background (mg/kg)[2]
Arsenic	14	5.225	95% Approximate Gamma UCL	5.04
Cadmium	35	8.103	95% Chebyshev (Mean, Sd) UCL	1.596
Copper	180	47.37	95% KM (Chebyshev) UCL	12.65
Lead	9500	1406	95% Chebyshev (Mean, Sd) UCL	44.87
Mercury	0.21	0.069	95% KM (Chebyshev) UCL	0.134
Zinc	11000	3027	97.5% KM (Chebyshev) UCL	206

COPEC = Contaminant of potential ecological concern

EPC = Exposure point concentration

1. 95 UCL concentrations used as recommended from the ProUCL program (USEPA 2010).

2. Background is calculated as the 90th percentile value for each contaminant (Hart Crowser 2012)

Table 9. EPCs - AOI4 Tailings Pipeline and Access Road

COPEC	Maximum Concentration (mg/kg)	Area-wide EPC (mg/kg)	Basis of EPC[1]	Site-Specific Background (mg/kg)[2]
Arsenic	21	9.699	95% Chebyshev (Mean, Sd) UCL	5.04
Cadmium	25	9.384	95% Chebyshev (Mean, Sd) UCL	1.596
Copper	81	30.57	95% H-UCL	12.65
Lead	1000	395.1	95% Chebyshev (Mean, Sd) UCL	44.87
Mercury	0.45	0.162	97.5% KM (Chebyshev) UCL	0.134
Zinc	7700	2538	95% Chebyshev (Mean, Sd) UCL	206

COPEC = Contaminant of potential ecological concern
EPC = Exposure point concentration

1. 95 UCL concentrations used as recommended from the ProUCL program (USEPA 2010).
2. Background is calculated as the 90th percentile value for each contaminant (Hart Crowser 2012)

Table 10. AOI1 Soil Hazard Quotients

	NOAEL-Based HQ				LOAEL-Based HQ	
	Plants	Invertebrates	Wildlife		Wildlife	
COPEC			Avian	Mammalian	Avian	Mammalian
Antimony	**1.5**	0.09	-	**8**	-	**3**
Arsenic	0.6	0.2	0.2	0.2	-	-
Cadmium	**1.3**	0.3	**53**	**26**	**12**	**11**
Copper	**1.8**	**1.6**	**4**	**3**	-	-
Lead	**61**	**4**	**162**	**130**	**162**	**68**
Mercury	**2**	**4**	0.1	0.1	-	-
Nickel	0.2	0.03	0.04	0.07	-	-
Silver	0.002	0.02	0.2	0.07	-	-
Thallium	0.4	-	-	0.4	-	-
Zinc	**49**	**49**	**49**	**49**	**49**	**49**

HQ = Area-wide EPC/soil benchmark value

Bold = HQ>1, identified as COEC

[green shading] = background-based HQ, since benchmark < background.

\- not calculated; benchmark unavailable or NOAEL-based HQ < 1.

Table 11. Summary of COECs for AOI1 Soils

COPEC	Receptor	NOAEL-Based HQ	LOAEL-Based HQ	COEC?
Antimony	Plants	1	NE	No
	Small mammals	**8**	3	Yes
Cadmium	Plants	1	NE	No
	Birds	**53**	**12**	**YES**
	Small mammals	**26**	**11**	**YES**
Copper	Plants	2	NE	Yes
	Invertebrates	2	NE	Yes
	Birds	4	1	No
	Small mammals	3	1	No
Lead	**Plants**	**61**	NE	**YES**
	Invertebrates	4	NE	Yes
	Birds	**162**	**162**	**YES**
	Small mammals	**130**	**68**	**YES**
Mercury	Plants	2	NE	Yes
	Invertebrates	4	NE	Yes
Zinc	**Plants**	**49**	NE	**YES**
	Invertebrates	**49**	NE	**YES**
	Birds	**49**	**49**	**YES**
	Small mammals	**49**	**49**	**YES**

AOI-1: Mill Facility, Open Pits and Waste Rock

Bold = HQ > 5, identified as indicator hazardous substance COEC

NE = not evaluated

Table 12. AOI2 Soil Hazard Quotients

COPEC	NOAEL-Based HQ				LOAEL-Based HQ	
	Plants	Invertebrates	Wildlife		Wildlife	
			Avian	Mammalian	Avian	Mammalian
Arsenic	0.3	0.1	0.1	0.1	-	-
Cadmium	0.2	0.1	**10**	**5**	**2**	**2**
Copper	0.6	0.6	**2**	0.9	0.5	-
Lead	**3**	0.2	**8**	**6**	**8**	**3**
Mercury	0.4	1.0	0.02	0.02	-	-
Zinc	**20**	**20**	**20**	**20**	**20**	**20**

HQ = Area-wide EPC/soil benchmark value

Bold = HQ>1, identified as COEC

(green shading) = background-based HQ, since benchmark < background.

\- not calculated; benchmark unavailable or NOAEL-based HQ < 1.

Table 13. Summary of COECs for AOI2 Soils

COPEC	Receptor	NOAEL-Based HQ	LOAEL-Based HQ	COEC?
Cadmium	Birds	**10**	2	Yes
	Small mammals	5	2	Yes
Lead	Plants	3	NE	Yes
	Invertebrates	<1	NE	No
	Birds	**8**	**8**	**YES**
	Small mammals	**6**	3	Yes
Zinc	Plants	**20**	NE	**YES**
	Invertebrates	**20**	NE	**YES**
	Birds	**20**	**20**	**YES**
	Small mammals	**20**	**20**	**YES**

AOI2 Upper Tailings Pile.

Bold = HQ > 5, identified as indicator hazardous substance COEC

NE = not evaluated

Table 14. AOI3 Soil Hazard Quotients

COPEC	NOAEL-Based HQ				LOAEL-Based HQ	
			Wildlife		Wildlife	
	Plants	Invertebrates	Avian	Mammalian	Avian	Mammalian
Arsenic	0.3	0.1	0.1	0.1	-	-
Cadmium	0.3	0.1	**11**	**5**	**2**	**2**
Copper	0.7	0.6	**2**	1	0.6	-
Lead	**12**	0.8	**31**	**25**	**31**	**13**
Mercury	0.2	0.5	0.01	0.01	-	-
Zinc	**15**	**15**	**15**	**15**	**15**	**15**

HQ = Area-wide EPC/soil benchmark value

Bold = HQ>1, identified as COEC

[green shading] = background-based HQ, since benchmark < background.

\- not calculated; benchmark unavailable or NOAEL-based HQ < 1.

Table 15. Summary of COECs for AOI3 Soils

COPEC	Receptor	NOAEL-Based HQ	LOAEL-Based HQ	COEC?
Cadmium	Birds	**11**	2	Yes
	Small mammals	5	2	Yes
Lead	Plants	**12**	NE	**YES**
	Invertebrates	<1	NE	No
	Birds	**31**	**31**	**YES**
	Small mammals	**25**	**13**	**YES**
Zinc	Plants	**15**	NE	**YES**
	Invertebrates	**15**	NE	**YES**
	Birds	**15**	**15**	**YES**
	Small mammals	**15**	**15**	**YES**

AOI3 Lower Tailings Pile.

Bold = HQ > 5, identified as indicator hazardous substance COEC

NE = not evaluated

Table 16. AOI 4 Soil Hazard Quotients

COPEC	NOAEL-Based HQ				LOAEL-Based HQ	
	Plants	Invertebrates	Wildlife		Wildlife	
			Avian	Mammalian	Avian	Mammalian
Arsenic	0.5	0.2	0.2	0.2	-	-
Cadmium	0.3	0.1	**12**	**6**	**3**	**3**
Copper	0.4	0.4	1	0.6	0.4	-
Lead	**3**	0.2	**9**	**7**	**9**	**4**
Mercury	0.5	1	0.03	0.03	-	-
Zinc	**12**	**12**	**12**	**12**	**12**	**12**

HQ = Area-wide EPC/soil benchmark value

Bold = HQ>1, identified as COEC

[green shading] = background-based HQ, since benchmark < background.

\- not calculated; benchmark unavailable or NOAEL-based HQ < 1.

Table 17. Summary of COECs for AOI4 Soils

COPEC	Receptor	NOAEL-Based HQ	LOAEL-Based HQ	COEC?
Cadmium	Birds	**12**	3	Yes
	Small mammals	**6**	3	Yes
Lead	Plants	**3**	NE	No
	Invertebrates	<1	NE	No
	Birds	**9**	**9**	**YES**
	Small mammals	**7**	4	Yes
Zinc	Plants	**12**	NE	**YES**
	Invertebrates	**12**	NE	**YES**
	Birds	**12**	**12**	**YES**
	Small mammals	**12**	**12**	**YES**

AOI4 Tailings Pipeline and Access Road.

Bold = HQ > 5, identified as indicator hazardous substance COEC

NE = not evaluated

Table 18. Sediment EPCs and Hazard Quotients

COPEC	EPC (mg/kg)	Basis of EPC	Site-Specific Background (mg/kg)	Benchmark Value (mg/kg)[1]	Hazard Quotient	COEC?
AOI 5 - Onion Creek						
Zinc	970	Maximum	120	459	2	**YES**
Zinc	405	95 UCL	120	459	0.9	No
Zinc	670	OC-7-SD	120	459	**1.5**	**YES**
Zinc	910	OC-8-SD	120	459	**2**	**YES**
Zinc	560	OC-9-SD	120	459	**1.2**	**YES**
Zinc	970	OC-11-SD	120	459	**2**	**YES**
Zinc	510	OC-18-SD	120	459	1	No

COPEC = Contaminant of potential ecological concern
COEC = Contaminant of ecological concern
EPC = Exposure point concentration
95 UCL = 95 percent upper confidence limit of mean of all Onion Creek sediment concentrations
Bold = HQ>1, identified as COEC
1. Consensus-based freshwater sediment quality criterion from USGS (Ingersoll et al. 2000)

Table 19. Surface Water EPCs and Hazard Quotients

COPEC	EPC (µg/L)	Basis of EPC	Benchmark (µg/L)[1]	Hazard Quotient	COEC?
AOI 1 Mill Facility, Open Pits and Waste Rock					
Cadmium	1.4	Maximum	1.03	**1.4**	**YES**
Lead	9.4	Maximum	2.52	**4**	**YES**
Zinc	720	Maximum	105	**7**	**YES**
AOI 2 Upper Tailings Pile					
Lead	5.3	Maximum	2.52	**2**	**YES**
Zinc	230	Maximum	105	**2**	**YES**
AOI 5 - Onion Creek					
Zinc	130	Maximum	105	1.2	Yes
Zinc	56.9	95 UCL	105	0.5	No

COPEC = Contaminant of potential ecological concern
COEC = Contaminan Contaminant of ecological concern
EPC = Exposure point concentration
95 UCL = 95 percent upper confidence limit of mean of all Onion Creek surface water concentrations
Bold = HQ>1, identified as COEC
1. Washington State water quality standards (WQS) for freshwater organisms, chronic (Ecology 2003)