SUNSET MINE AND MILLSITE

Mt. Baker-Snoqualmie National Forest
Snohomish County, Washington

STREAMLINED HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

May 25, 2006

Prepared For:
U.S. Forest Service, Region 6
10600 NE 51st Circle
Vancouver, Washington 98682

MSE
Millennium Science & Engineering, Inc.

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ACRONYMS AND ABBREVIATIONS

cm^2	Square centimeter
cm/hr	Centimeter per hour
cyd	Cubic yard
kg	Kilogram
L/cm^3	Liter per cubic centimeter
m^3/day	Cubic meter per day
m^3/kg	Cubic meter per kilogram
mg/cm^2/day	Milligram per square centimeter per day
mg/day	Milligram per day
mg/kg	Milligram per kilogram
mg/kg-day	Milligram per kilogram per day
mg/L	Milligram per liter
μg/L	Microgram per liter
ABA	Acid base accounting
APA	Abbreviated Preliminary Assessment
ATSDR	Agency for Toxic Substance Disease Registry
AWQC	Ambient water quality criteria
BLM	United States Bureau of Land Management
CDI	Chronic daily intake
CERCLA	Comprehensive Emergency Response, Compensation & Liability Act
CES	Cascade Earth Sciences
CNS	Central nervous system
COI	Contaminant of interest
COPC	Contaminant of potential concern
COR	Contracting Officer's Representative
CPEC	Contaminant of potential ecological concern
CSEM	Conceptual site exposure model
CSM	Conceptual site model
CTE	Central tendency exposure
ECR	Excess cancer risk
EE/CA	Engineering Evaluation/Cost Analysis
EF	Exposure factor
EPA	United States Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological risk assessment
HEAST	Health Effects Assessment Screening Tables
HHRA	Human health risk assessment
HI	Hazard Index
HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake Biokentic
IRIS	Integrated Risk Information System

ACRONYMS AND ABBREVIATIONS (continued)

LOAEL	Lowest observed adverse effects level
MCL	Maximum contaminant level
MDC	Maximum detected concentration
MDL	Method detection limit
MFSR	Middle Fork Snoqualmie River
MTCA	Model Toxics Control Act
NCEA	National Center for Environmental Risk Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFS	National Forest Service
NNP	Net neutralization potential
NOAEL	No observed adverse effects level
PPRTVS	Provisional Peer Reviewed Toxicity Values
PRG	Preliminary Remediation Goal
PQL	Practical quantitation limit
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RfD	Reference dose
RMC	Risk Management Criteria
RME	Reasonable maximum exposure
RTE	Rare, threatened, or endangered
SARA	Superfund Amendments and Reauthorization Act
SF	Slope factor
SI	Site Inspection
SLV	Screening level value
SOC	Species of concern
T&E	Threatened and endangered
UCL_{95}	95 percent upper confidence limit
USFS	United States Forest Service
WAC	Washington Administrative Code
WR	Waste rock
WSDH	Washington State Department of Health

EXECUTIVE SUMMARY

The Sunset Mine and Millsite is an inactive copper mine located about 5 miles northeast of Index, Washington, in the Mount Baker-Snoqualmie National Forest. Under contract to the USDA Forest Service (USFS), Millennium Science and Engineering, Inc. (MSE) completed streamlined human health and ecological risk assessments (RAs) to evaluate risks associated with exposure to mining-related contaminants at the site. Analytical data and other information presented in the Site Inspection (SI) Report by Cascade Earth Sciences (CES 2005) were used in the risk calculations. A hot spot assessment was completed and human health risk-based cleanup levels were developed for soil and sediment at the site. Physical hazards at the site were not addressed in this RA.

Streamlined human health and ecological RAs for the following pathways were completed to assess potential risks to human and ecological receptors at the site.

- **Groundwater Pathway:** The groundwater pathway at the site is considered incomplete because there are no groundwater uses at the site and there does not appear to be any wells within a 4-mile radius that are hydraulically connected to the site.
- **Surface Water Pathway:** The surface water ingestion pathway is complete and significant for both human and ecological receptors because of elevated metals concentrations in the surface water and sediment. The surface water dermal contact pathway is complete but insignificant because of low risk levels.
- **Soil/Sediment Pathway:** The soil/sediment ingestion and dermal contact pathways are complete and significant for both human and ecological receptors because of elevated metals concentrations in the waste rock, soil around the mill foundation, and sediment.
- **Air Pathway:** The air pathway is complete for human receptors but insignificant because of extremely low risk levels.

Based on results of the streamlined RAs, there are significant potential human health risks from exposure to metals, particularly arsenic, in mine waste, soil, sediment, and surface water at the site. Non-carcinogenic Hazard Indices (HIs) ranged from 0.04 to 1 for the adult recreationalist, and from 0.4 to 23 for the child recreationalist. Carcinogenic risks ranged from 7.E-07 to 4.E-05 for the adult recreationalist, and from 4.E-06 to 2.E-04 for the child recreationalist. Eight human health contaminants of potential concern (COPCs) were identified at the site: antimony, arsenic, cadmium, chromium, copper, iron, lead, and mercury. The most significant exposure pathway is ingestion of and dermal contact with arsenic in the mine waste.

There is also significant potential risk to ecological receptors at the site and several contaminants of potential ecological concern (CPECs) were identified, most notably aluminum, arsenic, copper, iron, mercury, and selenium. The highest risk ratios are from exposure to the mine waste for terrestrial receptors. There is also risk to aquatic receptors from exposure to surface water and sediment, particularly from exposure to copper. However, even though the risk ratios are very high, the risks appear to be limited to individual receptors rather than whole populations. This is because while individual receptors may be exposed to metals in mine wastes at the site, their populations are unlikely to be significantly impacted because it is improbable that entire populations of receptors reside strictly within the site boundaries. However, some sensitive species, such as the Oregon spotted frog or western toad, may have individual receptors that are at risk because they have much smaller home ranges and may inhabit areas around the adit discharges.

Several state or federal rare, threatened, or endangered (RTE) ecological species have potential habitat in vicinity of the site. In addition, bull trout, Coho salmon, and Chinook salmon (federally threatened species) were not observed on site, but have been documented previously in Trout Creek and the North Fork Skykomish River during their spawning and rearing life cycle. There are also several RTE plant species that may be present on the site. Therefore, a risk ratio for sensitive protected species (Q = 1) was used to evaluate potential ecological risks to birds, mammals, plants, and aquatic life; no RTE invertebrates were identified so a risk ratio of Q = 5 was used for invertebrates.

A hot spot assessment was completed and human health risk-based cleanup criteria were back calculated for soil and sediment using the human health exposure factors (EFs) and risk equations. Arsenic and copper were the only contaminants to exceed the soil hot spot concentrations of 410 milligram per kilogram (mg/kg) and 365,730 mg/kg, respectively. Two areas were identified as hot spots: (1) waste rock pile WR-2 (arsenic = 1,150 mg/kg), and (2) waste rock pile WR-5 (copper = 883,000 mg/kg).

Twelve soil samples from five areas exceeded the risk-based cleanup levels. Arsenic concentrations exceeded the cleanup level of 41 mg/kg in samples from all five areas: soil south of the mill foundation, waste rock pile WR-1, waste rock pile WR-2, waste rock pile WR-5, and waste rock pile WR-6. Copper and antimony concentrations in one sample from waste rock pile WR-5 also exceeded the cleanup level of 36,573 mg/kg and 883,000 mg/kg, respectively. The total volume of waste rock in the four waste rock piles was estimated in the SI to be about 1,110 cubic yards (CES 2005). No sediment samples exceeded the cleanup levels.

Addressing or mitigating the human health risks through a removal action should also address the potential ecological risks. In general, the areas containing the highest arsenic and copper concentrations in soil also contain the highest concentrations of the other COPCs. Therefore, removal of waste rock and soil from the areas with arsenic and copper concentrations exceeding the cleanup levels should significantly reduce both the overall human health and potential ecological risk at the site. Removal of the waste rock should also significantly reduce metals loading to Trout Creek from sheet flow and erosion of the waste rock piles; however, the adit discharges will continue to be a source of metals loading to Trout Creek and a potential risk to human and ecological receptors at the site.

Based on the results of the streamlined RAs, MSE recommends performing a streamlined Engineering Evaluation/Cost Analysis (EE/CA) to address metals concentrations in the mine waste, soil, sediment, and surface water at the site.

1.0 INTRODUCTION

This report presents streamlined human health and ecological risk assessments (RAs) for the Sunset Mine and Millsite, in the Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington. The streamlined RAs were completed to evaluate risks associated with exposure to mining-related contaminants at the site using analytical data and other information presented in the Site Inspection (SI) Report by Cascade Earth Sciences (CES 2005). A hot spot assessment also was completed to identify highly contaminated areas, and human health risk-based cleanup levels were developed for soil and sediment at the site. Physical hazards at the site were not addressed in this RA.

This report describes the risk assessment methodology, assumptions, and potential risks to human and ecological receptors, and is organized into the following sections:

- Introduction
- Data Review
- Initial Risk Screening
- Streamlined Human Health Risk Assessment
- Streamlined Ecological Risk Assessment
- Conclusions
- References

A detailed description of the site location, background, field investigation, and physiography is presented in the SI (CES 2005) and will not be reiterated here. Summary tables are presented at the end of the report; human health and ecological risk calculation tables are presented in Appendices A and B, respectively. A supplemental list of threatened and endangered (T&E) wildlife and plant species, and species of concern (SOC) is provided in Appendix C.

1.1 Site Description

The Sunset Mine and Millsite is an inactive copper mine located about 5 miles northeast of Index, Washington, in the Mount Baker-Snoqualmie National Forest. Site features include:

- One open ventilation raise;
- Two large caved stopes;
- One open adit (Adit 1) with discharge;
- Two collapsed adits (Adits 2 and 3), including one with discharge (Adit 2);
- Six waste rock piles; and
- Concrete mill foundation and miscellaneous debris.

The project site is located along a moderate to steep, heavily forested slope adjacent to a perennial stream at an elevation of about 1,300 feet. The stream, Trout Creek, is a tributary to the North Fork of the Skykomish River (NFSR). Waste rock piles WR-1, WR-2, and WR-3 are located close to Trout Creek near the mill foundation, and waste rock piles WR-3, WR-4, and WR-5 are located from about 600 to 900 feet up the hillside. The estimated volumes of waste rock are summarized in Table 1. No tailings were reported in the SI; however, it's likely that tailings from the mill were deposited in Trout Creek.

Adit 2 is about 300 feet from the mill foundation, Adit 1 is adjacent to waste rock pile WR-6, and Adit 3 is near waste rock pile WR-4. Water discharges from Adit 2 at 150 to 450 gallons per minute (gpm) and flows west about 500 feet to Trout Creek. Water also discharges from Adit 1 but the rate was not reported in the SI and the flow was reported to infiltrate into the ground about 50 feet from the adit.

The open ventilation raise and west caved stope are about 150 feet north/northwest of waste rock pile WR-4, and the east caved stope is on the northern side of waste rock pile WR-5. The caved stopes and ventilation raise pose extreme physical hazards at the site.

1.2 Previous Investigations

In 2002, the Washington Department of Natural Resources (WA-DNR) collected water samples at the site as part of the State's Inactive and Abandoned Mine Lands (IAML) inventory. Samples were collected from Trout Creek upstream and downstream of the site, and from the Adit 2 discharge. The samples were submitted for analysis of total metals. All of the samples exceeded the Washington state chronic standard for copper. The highest copper concentration (96 micrograms per liter [μg/L]) was in the downstream sample from Trout Creek. The maximum detected arsenic and zinc concentrations were 19 μg/L and 33 μg/L, respectively. Surface water pH ranged from 5.5 to 5.9.

An Abbreviated Preliminary Assessment (APA) was completed by the U.S. Forest Service (USFS) in September 2003. Metals concentrations at the site were assessed *in situ* using an x-ray fluorescence analyzer. Samples were also collected for bench top testing. Arsenic was detected at concentrations ranging from 47.8 to 290 milligrams per kilogram (mg/kg), and was the only detected compound that exceeded U.S. Environmental Protection Agency (EPA) Region IX Industrial Soil Preliminary Remediation Goals (PRGs). The APA recommended that an SI be performed.

An SI was completed in July 2005 by Cascade Earth Sciences (CES). SI activities included:

1) Researching and reviewing relevant background site information;
2) Conducting a field investigation and collecting samples for laboratory analysis;
3) Conducting aquatic, plant, and wildlife surveys of the site; and
4) Estimating mine waste volumes.

The site is currently inactive but there are outstanding mineral rights on site. According to the SI, there are approximately 40 houses and 10 wells within a 4-mile radius of the site (CES 2005). However, all of the houses are located below the confluence with the NFSR and the nearest house is about 1.9 miles downstream of the site. Of the 10 wells, 9 obtain water from the unconsolidated alluvial deposits associated with the NFSR and impacts to these wells from the site are highly unlikely. The tenth well is located in a different watershed over 2 miles from the site and is also unlikely to be affected from the site. Therefore, the groundwater pathway at the site is considered to be incomplete.

There are no developed recreational areas in the site vicinity; however, recreational use of the site is reported to be moderate and include hiking, fishing, camping, hunting, timber harvesting, firewood cutting, and minerals prospecting. Although public access to the site is not maintained, public exploration of the site is encouraged in *Discovering Washington's Historic Mines* (Northwest Underground Explorations 1997) and several hikers were reportedly encountered during the SI field activities.

No terrestrial sensitive or threatened and endangered (T&E) species were observed on the site during the SI; however, several may habitat in the area. Several T&E fish species, including Coho salmon, resident

rainbow trout, fall Chinook salmon, and bull trout are known to inhabit Trout Creek and the NFSR. There are also several T&E mammal, bird, and herpetile species that have the potential to habitat in vicinity of the site, including the rocky mountain tailed frog, western toad, spotted frog, bald eagle, pileated woodpecker, fisher, Columbia black-tailed deer, Canada lynx, and others. Sensitive plants also potentially occur on site, including marsh sandwort, golden paintbrush, water howellia, Kincaid's lupine, Nelson's checker-mallow, and Bradshaw's desert parsley.

During the SI, the CES collected samples of the following media and submitted for laboratory analysis:

- Mine waste – 14 samples;
- Background soil – 3 samples;
- Surface water – 8 samples, including 1 background and 2 from the NFSR;
- Pore water – 4 samples co-located with 4 surface water sample locations, including 1 background and 1 from the NFSR;
- Sediment – 4 samples co-located with 4 surface water sample locations, including 1 background and 1 from the NFSR;
- Plant tissue – 6 samples co-located with soil and mine waste samples, including 3 background; and
- Benthic macroinvertebrates – samples collected from pool and riffle habitats along stream reaches at 4 locations.

Analytical results of the surface water samples indicated elevated concentrations of metals, particularly in the adit discharges. Surface water, pore water, and sediment samples from Trout Creek and the NFSR also contained slightly elevated concentrations of metals, most notably arsenic, barium, copper and nickel. However, there are reportedly several mines and associated disturbances upstream of the site within the Trout Creek watershed that may be contributing to the elevated metals concentrations. The mine waste samples also contained elevated concentrations of several metals and acid base accounting (ABA) results indicate a potential for acid generation.

The SI concluded that an Engineering Evaluation/Cost Analysis (EE/CA) should be performed and should include human health and ecological RAs. The SI also recommended an additional surface water sampling event to evaluate water quality during low flow conditions.

1.3 Purpose and Objectives

The streamlined RAs were prepared to assess potential hazards and risks to human and ecological receptors from exposure to mine waste and contaminated media at the Sunset Mine and Millsite. The primary objectives of the RA were to:

- Determine 95 percent Upper Confidence Level (UCL_{95}) concentrations;
- Assess potential risks to human and ecological receptors at the site;
- Identify hot spots, i.e. highly contaminated areas that contribute a large percentage of the overall site risk; and
- Establish appropriate risk-based, site-specific, cleanup levels.

2.0 DATA REVIEW

Analytical results presented in the SI were tabulated and reviewed to ensure suitability for use in the RA. Data used in the RA included results of background soil, mine waste (waste rock), surface water, pore water, sediment and vegetation samples collected during the SI. The analytical results are summarized by media type in Tables 2 through 6.

The method detection limit (MDL) for analytical results reported as below the MDL were compared to human health and ecological screening criteria to ensure the MDLs were below the applicable criteria. In surface water, the MDLs for beryllium, cadmium, selenium, and nickel were above one or more ecological screening criteria. The MDL for beryllium (2 μg/L) for all surface water samples was above the Oak Ridge National Laboratory (ORNL) PRG (0.66 μg/L) for ecological endpoints (Efroymson *et al.* 1997). The selenium MDL (1.0 μg/L) for the three adit discharge samples was also slightly above the ORNL PRG (0.36 μg/L). The nickel MDL (10 μg/L) for all surface water samples was above EPA's recommended ambient water quality criteria for freshwater aquatic life (5.6 μg/L adjusted for hardness). The cadmium MDL (0.1 to 0.2 μg/L) for all surface water samples was also above EPA's recommended ambient water quality criteria (AWQC) for freshwater aquatic life (0.04 μg/L adjusted for hardness).

In pore water, the beryllium MDL (2 μg/L) was above the ORNL PRG (0.66 μg/L) for ecological endpoints (Efroymson *et al.* 1997). The cadmium MDL (0.1 μg/L), chromium III MDL (10 μg/L), and nickel MDL (10 μg/L), were all above EPA's recommended AWQC for freshwater aquatic life (0.03 μg/L, 8.6 μg/L, and 4.8 μg/L, adjusted for hardness). The zinc MDL (10 μg/L) was slightly above Washington's aquatic life criteria (9.64 μg/L).

In waste rock and soil, the MDLs for several analytes varied significantly and, in several instances, exceeded both ecological and human health screening criteria. The most notable exceedances were for antimony, arsenic, cadmium, selenium, and zinc. Presumably, the high MDLs were a result of laboratory dilutions necessitated by high metal concentrations in the mine waste and soil samples.

The surface water results were provided as total concentrations for all analytes; however, the screening criteria for some analytes are presented as dissolved concentrations. For those analytes, the screening criteria were converted to total concentrations using the conversion factors incorporated in the criterion equations (WDOE 2003a, Oregon Department of Environmental Quality [ODEQ] 2001). Similarly, for those analytes that are hardness dependent, the criteria were adjusted based on the average surface water and pore water hardness (WDOE 2003a, ODEQ 2001).

The maximum detected concentration (MDC), mean concentration, and UCL_{95} of the arithmetic mean concentration were determined for the contaminants of interest (COIs) in all media. For determining the average and UCL_{95} concentrations, samples with undetected concentrations were conservatively included at concentrations equal to ½ the laboratory reporting limit. Samples with concentrations detected above the MDL but below the practical quantitation limit (PQL) were included at the reported concentration. Because of the uncertainty associated with estimating true average concentrations at a site, UCL_{95} concentrations were computed using EPA's PROUCL statistical program. The program computes UCL_{95} concentrations for each data set using several methods and recommends one based on the data distribution. A minimum of four data points are required; therefore, UCL_{95} concentrations were computed only for mine waste and surface water because fewer than four samples were collected from the other media and background sources.

The two surface water (NFSR-SW1 and NFSR-SW2) and co-located sediment (NFSR-SS1) and pore water (NFSR-PW1) samples collected from the NFSR were not considered to be representative of the site or background conditions. Both locations are a considerable distance from the site and are subject to effects from other potential sources. In addition, a comparison of the surface water sample results from the two locations does not indicate any significant effects from the site. Therefore, analytical results of those samples were excluded from the site data set for calculating the minimum, maximum, or average contaminant concentrations.

3.0 INITIAL RISK SCREENING

The maximum detected COI concentrations were compared to U.S. Bureau of Land Management (BLM) Risk Management Criteria (RMCs) to provide a preliminary qualitative assessment of potential risk to human and ecological receptors at the site. The RMCs were developed as a screening tool for quickly assessing overall risks to humans and wildlife at abandoned mining sites and are based on the most problematic metals (Sb, As, Cd, Cu, Pb, Mn, Hg, Ni, Se, Ag, Zn) typically found at abandoned mine sites, on available toxicity data, and standard EPA exposure assumptions (Ford 1996). Comparing the maximum detected COI concentrations to the RMCs provides risk in logarithmic terms, with relative risk expressed in terms of the factor by which COI concentrations exceed the reference RMC. This initial risk screening process is intended to provide only a general level of risk and is, therefore, independent of the streamlined quantitative RAs. The results of the RMC screening are summarized in Table 7 and discussed in the following sections.

3.1 Human Health Risk Screening

Ford developed human health RMCs for soil, sediment, and surface water based on exposure scenarios that could potentially occur at abandoned mine sites, including camper, all-terrain vehicle driver, worker, surveyor, boater, swimmer, and resident. The RMCs correspond to either a target Excess Cancer Risk (ECR) of 1.E-05, or a target non-carcinogenic Hazard Index (HI) of 1.0. For metals posing both carcinogenic and non-carcinogenic threats to health, the lower (more protective) concentration is used for the RMC. For a target ECR of 1.E-05, an individual exposed at the RMC under the BLM exposure conditions, would have a 1 in 100,000 chance to develop any type of cancer in a lifetime as a result of contact with the metal of concern. An HI of <1.0 is assigned when the dose of non-carcinogenic metals assumed to be received at the site by any of the receptors is lower than the dose that may result in adverse non-carcinogenic health effects. The RMCs are protective for exposures to multiple chemicals and media. Because of the limited available toxicological information regarding health risks associated with exposure to lead, the lead RMC was determined from the EPA Integrated Exposure Uptake Biokinetic (IEUBK) Model and other EPA regulations and guidance (Ford 1996). The RMCs apply to soil, mine waste, sediment and surface water at the site.

The maximum detected COI concentrations in the mine waste, background soil, sediment, and surface water samples collected during the SI were compared to the RMCs for two receptor classifications: (1) camper, and (2) swimmer. Antimony, arsenic and copper were the only COIs to exceed human health RMCs. The initial risk screening results, shown in Table 7, indicate an extremely high risk to human receptors from exposure to copper, and a moderate risk from exposure to arsenic in mine waste at the site. However, the risk from exposure to antimony and the extreme risk from exposure to copper are based on unusually high concentrations in a single sample (SM-WR5-1). With the exception of this sample, there appears to be no risk from exposure to antimony and only moderate risk from exposure to copper in the mine waste. There does not appear to be a significant human health risk from exposure to sediment or surface water at the site.

3.2 Ecological Risk Screening

Ford developed ecological RMCs for soil from a survey of literature for toxicity data relevant to either wildlife receptors at BLM sites or to closely related species. For receptors without available toxicity data, Ford selected data based on phylogenetic similarity between ecological receptors and the test species for which toxicity data were reported. He obtained soil ingestion data for each receptor from a study on dietary soil content of wildlife from the FWS. For receptors without available dietary soil content data, he assumed soil content was equal to that of an animal with similar diets and habits. The amount of soil ingested by each receptor was estimated as a proportion of their daily food intake. Ford then calculated the food intake in grams for each receptor as a function of body weight based on scaling factors specific to each type of species.

Ford calculated RMCs for metals in soil based upon assumed exposure factors (EFs) for the specific receptors and species- and chemical-specific toxicity reference values (TRVs). The TRVs represent daily doses of the metals for each wildlife receptor that will not result in any adverse toxic effects. Ford computed the metals TRVs for each wildlife receptor/metal combination for which toxicity data were available. Phylogenetic and intraspecies differences between test species and ecological receptors were accounted for by applying uncertainty factors derived from critical toxicity values. These uncertainty factors were applied to protect wildlife receptors that might be more sensitive to the toxic effects of a metal than the test species. The uncertainty factors were applied to the test species toxicity data in accordance with a method developed by BLM. In accordance with this system, Ford applied a divisor of two to the toxicity reference dose for each level of phylogenetic difference between the test and wildlife species (in essence, individual, species, genus, and family).

The maximum detected COI concentrations in the mine waste and background soil were compared to ecological RMCs for six potential receptors: deer mouse, mule deer, elk, mallard, Canada goose, and robin. The initial mine waste screening results, shown in Table 7, indicate extremely high risk to all receptors from exposure to copper, moderate to extremely high risk to all receptors from exposure to arsenic and lead, and moderate to high risk to all receptors from exposure to zinc. There is also moderate to high risk to all receptors except the deer mouse from exposure to cadmium, and moderate risk to the deer mouse, mallard, and robin from exposure to mercury. The background soil results, also shown in Table 7, indicate high risk to the robin from exposure to copper, and moderate risk from exposure to arsenic, cadmium, lead, and zinc. There is also moderate risk to all receptors except the deer mouse from exposure to copper in the background soil.

4.0 STREAMLINED HUMAN HEALTH RISK ASSESSMENT

The streamlined human health risk assessment (HHRA) was prepared to assess potential hazards and risks to human receptors from exposure to mine waste and contaminated media at the site. The HHRA used analytical data and other information gathered during the SI by CES in July 2005 and site-specific EFs based on the anticipated receptors and future land uses. Both central tendency exposure (CTE) and reasonable maximum exposure (RME) scenarios were evaluated. The HHRA was prepared in general accordance with state and federal regulations and guidelines, including:

- Comprehensive Environmental Restoration and Compensation Liability Act (CERCLA);
- Superfund Amendments and Reauthorization Act (SARA);
- National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40CFR 300.415(b)(4)(i);

- EPA's *"Risk Assessment Guidance for Superfund Volume I – Human Health Evaluation Manual Part (A)",* 1991;
- Washington's Model Toxic Act (MTCA) (WDOE 2001a); and
- Washington Administrative Code (WAC) 173-340.

The streamlined HHRA process consisted of the six steps listed below:

Step 1 – Exposure Assessment
Step 2 – Toxicity Assessment
Step 3 – Risk Characterization
Step 4 – Uncertainty Analysis
Step 5 – Hot Spot Assessment
Step 6 – Development of Risk-based Cleanup Levels

Each step is discussed in the following sections and summary tables are provided at the end of the report. Human health risk calculation tables are provided in Appendix A.

4.1 Exposure Assessment

The exposure assessment involved preparing a conceptual site model (CSM), identifying the potentially exposed populations at the site, determining the potentially complete exposure pathways, identifying the contaminants of potential concern (COPCs), estimating EPCs, and developing a set of EFs and assumptions for use in the risk calculations. Each of these tasks is described in the following sections.

4.1.1 Human Health Conceptual Site Model

A human health CSM, shown in Figure 1, was prepared for the Sunset Mine and Millsite to provide a framework for assessing risk by identifying the following:

- The environmental setting and contaminants known or suspected to exist at the site
- Contaminant fate and transport mechanisms that might exist at the site
- Mechanisms of toxicity associated with contaminants and potential receptors
- Complete exposure pathways that might exist at the site
- Potential exposed populations

The Sunset Mine CSM was based on information provided in the SI and should be representative of current and likely future conditions at the site.

4.1.2 Potentially Exposed Populations

The Sunset Mine and Millsite is in a relatively remote location about 2 miles from the nearest house. Although there are no developed recreational areas near the site, public exploration of the site is encouraged in *Discovering Washington's Historic Mines* (Northwest Underground Explorations 1997) and recreational use of the site is likely moderate. Recreational uses are likely to include hiking, fishing, camping, hunting, timber harvesting, firewood cutting, swimming, and minerals prospecting. Future uses

of the site are expected to remain the same as current uses. Residential development of the site is believed to be unlikely; therefore, the risk of long-term exposure to contaminants at the site is considered low.

The primary receptors evaluated in this streamlined HHRA and anticipated to visit the site include:

- Recreationalist – Adult Receptor
- Recreationalist – Child Receptor

4.1.3 Potentially Complete Exposure Routes

Based on the anticipated receptors, the following exposure pathways were evaluated:

- Incidental ingestion of mine waste (waste rock) and sediment;
- Ingestion of surface water as a drinking source;
- Dermal contact with mine waste, surface water, and sediment; and
- Inhalation of mine waste particulates.

Other potentially complete pathways, such as groundwater ingestion, plant ingestion, and fish tissue ingestion were qualitatively considered but not quantified. The groundwater pathway at the site is considered incomplete because there are no groundwater uses at the site and there does not appear to be any nearby wells that are hydraulically connected to the site. Vegetation samples collected during the SI consisted of vine maple species, which is non-palatable; however, several palatable species, such as the salmonberry, elderberry, and huckleberry were documented on site during the SI (CES 2005). Although these palatable plants likely contain elevated levels of metals, the fruit is relatively small and it is unlikely that a large quantity would be consumed. It's also unlikely that the site will be used for agricultural cultivation; therefore, plant ingestion was determined to be a potentially complete but insignificant pathway. No fish were observed in Trout Creek during the SI; however, they likely inhabit the stream and their tissue may contain elevated levels of COIs. Although health risks resulting from ingestion of fish can be estimated based on COI concentrations in the surface water, Trout Creek is a relatively small stream with a limited population of fish and would only be fished on a limited basis. Therefore, risks from ingestion of fish were not quantified because any fish caught from the stream would likely represent an insignificant fraction of any individual's diet.

4.1.4 Contaminants of Potential Concern

Analytical results of mine waste, sediment, and surface water samples collected during the SI were screened in accordance with EPA guidance (EPA 2001) to identify COPCs. The screening process consisted of three steps: (1) determining the frequency of detection, (2) comparing to background concentrations, and (3) comparing to established criteria for potential toxicity. The essential nutrients (calcium, iron, magnesium, potassium, and sodium) were not present at concentrations that would pose a threat to human health; therefore, they were removed from further analysis.

Frequency of Detection Screening – COIs detected in fewer than 5 percent of the samples site-wide for a given media were eliminated from further screening. In mine waste, all COIs were detected in more than 5 percent of the samples. However, because of the small quantity of samples collected from the other media, a detected result in only a single sample would constitute a detection frequency of more than 5 percent. Therefore, only COIs that were not detected in any samples for each media

were eliminated based on the frequency of detection screening. In sediment, beryllium, mercury, selenium and cyanide were not detected in any of the samples. In surface water, beryllium, chromium, cobalt, nickel, selenium, vanadium, and zinc were not detected in any of the samples.

Comparison with Background Concentration Screening – COIs with MDCs below the mean background concentrations were eliminated from further screening. Mean background concentrations were used because UCL_{95} concentrations could not be computed using the PROUCL program due to the small quantity of background samples. In mine waste, all COIs were above background, and in sediment, only cadmium, lead, and silver were below background. In surface water, thallium was the only COI detected below background.

Concentration-risk Screening – The COI MDCs were compared to the lower of (1) EPA Region IX Industrial Soil PRGs (2004a), and (2) MCTA Method A Soil Cleanup Levels for industrial properties (WDOE 2001b). Industrial criteria were used for mine waste and sediment because there are no established criteria for a recreational use scenario and residential development of the site is believed to be unlikely. However, it should be noted that the industrial criteria are very conservative for this site because they are typically based on an occupational scenario with 250 days of exposure per year, which is much greater than would be expected for recreational use. For surface water, the MDCs were compared to the lower of (1) EPA Region IX Tap Water PRGs (2004a), and (2) State of Washington Drinking Water Criteria, WAC 246-290 (Washington State Department of Health [WSDH] 2006). The concentration risk screening also evaluated potential cumulative effects of individual COIs across multiple media, as well as multiple COIs within each media and across multiple media.

In addition to risk from individual COIs in each media, the concentration-risk screening also evaluated potential cumulative effects from exposure to multiple COIs across each media, as well as from exposure to a single COI across multiple media. The risk from exposure to multiple COIs across a single medium is evaluated by dividing each single COI risk ratio by the sum of risk ratios for the medium. A result greater than 1 divided by the number of risk ratios indicates risk. The risk from exposure to a COI across multiple media is evaluated by summing the COI's risk ratio for each medium; a total risk ratio greater than or equal to 1, indicates risk.

Results of the screening process are summarized in Table 8; eight COPCs were identified: antimony, arsenic, cadmium, chromium, copper, iron, lead, and mercury. Arsenic, cadmium, chromium, copper, iron, and mercury were identified as COPCs in mine waste. Arsenic was also identified as a COPC in surface water and sediment, and chromium was identified as a COPC in sediment. The remaining COPCs (antimony and lead) were identified as COPCs based on exposure to multiple COIs across multiple media.

4.1.5 Exposure Point Concentrations

The EPC is used in the risk calculations and is defined as the concentration that a receptor will potentially contact during the exposure period. EPCs were estimated for each COPC from the analytical results of samples collected during the SI. Because of the uncertainty associated with estimating the true average concentration at a site, UCL_{95} concentrations were used for the RME EPC in mine waste and surface water. However, because of the relatively small data sets and non-parametric data distribution, the computed UCL_{95} concentration for some COPCs exceeded the MDC. In those instances, the MDC was used as the EPC. The MDC was also used for sediment because fewer than four sediment samples were collected and UCL_{95} concentrations were not computed. For the CTE scenario, the arithmetic mean concentration was used as the EPC for all media in accordance with EPA guidance (EPA 1991).

The EPCs used in this HRHA are summarized in Table 9.

4.1.6 Exposure Factors and Assumptions

EFs are assumed variables that are used with EPCs in the risk characterization equations to calculate contaminant exposures based on receptor body weight, exposure frequency and duration, averaging time, intake rates, chemical bioavailability, and other factors. The EFs used in the Sunset Mine HHRA were derived from a combination of site-specific conditions and standard default values presented in risk assessment guidance documents (EPA 1997a, 2004) and are summarized in Table 10.

4.2 Toxicity Assessment

The toxicological properties of COPCs identified in the exposure assessment were evaluated to determine the types and severity of potential health hazards associated with each COPC. Toxicological values for use in the risk equations were obtained from EPA's Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), and Department of Energy's Risk Assessment Information System (RAIS). Although subchronic exposures may be most representative of actual exposure times at the site, toxicity values for chronic exposure, i.e., from 7 years to a lifetime, were used to be conservative. The non-carcinogenic and carcinogenic toxicity values are summarized in the human health risk calculation tables (Tables A.5 and A.6, respectively).

4.3 Risk Characterization

Potential non-carcinogenic hazards, carcinogenic risks, and lead risks to human receptors at the site were estimated using the EPA risk assessment methodology and equations presented in the following subsections (EPA 1991).

4.3.1 Chronic Daily Intake

The chronic daily intake (CDI) represents the estimated daily exposure in milligrams per kilogram per day (mg/kg-day) to a contaminant at the site based on site-specific EFs and other parameters. CDIs are calculated for each exposure pathway and media using the following equations:

Ingestion:
$$CDI = \frac{CS \times IR \times EF \times ED \times CF}{BW \times AT}$$

Dermal Contact (soil):
$$CDI = \frac{CS \times SA \times SSAF \times DAF \times EV \times EF \times ED \times CF}{BW \times AT}$$

Dermal Contact (water):
$$CDI = \frac{CS \times SA \times Kp \times EV \times Tev \times EF \times ED \times CF}{BW \times AT}$$

Inhalation:
$$CDI = \frac{CS \times IN \times EF \times ED}{BW \times AT \times PEF}$$

Where:

CS = Contaminant concentration (mg/kg or milligram per liter [mg/L])

IR = Ingestion rate (milligram per day [mg/day])

EF = Exposure frequency (day per year)

ED = Exposure duration (year)

EV = Events per day

Tev = Time per event (hour/event)

CF = Conversion factor (kg/mg or liter per cubic centimeter [L/cm^3])

BW = Body weight (kg)

AT = Averaging time (day)

DAF = Dermal absorption factor (unitless)

SA = Skin surface area (square centimeter [cm^2])

SSAF = Soil to skin adherence factor (milligram per square centimeter per day [$mg/cm^2/day$])

Kp = Dermal permeability coefficient (cm/hr)

IN = Inhalation rate (cubic meter per day [m^3/day])

PEF = Particulate emission factor (cubic meter per kilogram [m^3/kg])

4.3.2 Non-carcinogenic Hazards

Non-carcinogenic hazards are evaluated by comparing the CDIs for each exposure pathway and media with EPA-established reference doses (RfDs). RfDs are COPC-specific toxicological values developed by the EPA to represent route-specific estimates of the safe dosage for each COPC over a lifetime of exposure. Potentially adverse health affects can occur if the CDI exceeds the RfD. RfDs can be classified as chronic or subchronic depending on the length of exposure. Although subchronic RfDs may be more representative of actual site conditions, chronic RfDs represent the highest average daily exposure to a human receptor that will not cause adverse health effects during their lifetime; therefore, to be conservative chronic RfDs were used. A non-carcinogenic Hazard Quotient (HQ) is computed for each COPC and exposure pathway by dividing the CDI by the RfD:

$$Non-carcinogenic\ HQ = \frac{CDI}{RfD}$$

Where:

CDI = Chronic daily intake; the estimated exposure over a given time

RfD = Reference dose; the exposure level above which represents potential adverse health effects

Individual HQs are determined for all COPCs in each exposure pathway. HQ or HI values greater than 1 indicate the potential for adverse health effects because the estimated intake exceeds the safe dosage. Generally, if two or more COPCs have the same target organ or similar effects, their HQs are summed to determine a HI. For example, two COPCs that both have an effect on the liver would be summed into an

HI. However, if one COPC affects the liver and the other COPC affects the central nervous system (CNS), their affects are not considered additive and their HQs are usually not summed into an HI. However, when there is a carcinogenic COPC at high concentrations, such as arsenic, carcinogenic risk will typically drive the human health risk and non-carcinogenic hazards will not be a factor. Therefore, because arsenic is present at relatively high concentrations at this site, the individual HQs were conservatively summed into an HI without regard for the target organ.

4.3.3 Carcinogenic Risks

The carcinogenic risk from exposure to a COPC is expressed in terms of the probability that an exposed receptor will develop cancer over their lifetime. Carcinogenic risks are estimated by multiplying the CDIs by COPC-specific slope factors (SFs) developed by the EPA:

$$Carcinogenic\ Risk = CDI \times SF$$

Where:

CDI = Chronic daily intake averaged over a lifetime; i.e., the estimated lifetime exposure at the site

SF = Slope factor; the upper-bound estimate of probability of cancer per unit of intake over a lifetime

The SF converts the contaminant intake to a risk of developing cancer from the exposure (i.e., ECR). SFs are chemical- and route-specific and represent an upper bound individual lifetime ECR. The ECR from each COPC in an exposure pathway are summed to determine the cumulative risk for each pathway and the cumulative risks from each pathway are summed to determine the overall site risk. ECRs greater than 1.E-06 indicate carcinogenic risk; however, the EPA suggests considering a range of ECRs from 1.E-06 to 1.E-04 when determining whether risks warrant a removal action (EPA 1991).

4.3.4 Lead Risks

Risks from exposure to lead cannot be quantified using standard risk assessment algorithms because lead RfDs and SFs have not been established by the EPA. The EPA currently recommends two models (IEUBK and ALM) for assessing lead risk based on the receptor age group; however, both models were developed to assess exposures under chronic, steady-state conditions such as a working environment, school, or residence (EPA 2002 and 2005a). The models are not intended to be used for acute, short-term exposures such as those associated with occasional recreational use of a remote site. Therefore, because exposures at the site are expected to be short-term and occasional, the lead exposure models were not used and lead risks were not quantitatively evaluated. However, lead risks were qualitatively evaluated by comparing the maximum detected lead concentrations at the site to EPA screening criteria and the BLM RMC for lead.

4.4 Uncertainty Analysis

The estimates of exposure, non-carcinogenic hazard, and carcinogenic risk presented in this HHRA are subject to varying degrees of uncertainty from a variety of sources, including site data, exposure assessment, and risk characterization. These uncertainties and their potential influence on results of this HHRA are discussed in the following sections.

4.4.1 Site Data

The size of the data set, sample locations, and sample analyses can all contribute uncertainty to the risk assessment. In general, smaller data sets lend more statistical variability to estimates of contaminant concentrations and may over or under estimate the true mean or maximum concentration. Also, background concentrations were based on very small data sets (three or fewer samples) and may not be representative of actual background conditions. Use of these background concentrations to screen COIs may result in screening out potential contaminants that could be above true background levels.

The intent of sampling during an SI is typically to determine metals concentrations in areas of suspected contamination, such as mine waste piles and adit discharges. Based on the methodology used for sample collection during the SI, the samples are expected to be biased to the highest concentrations present on the site and do not represent an average site concentration. Therefore, exposure doses based on the results of these non-random SI samples are expected to be biased to the upper end of the range of exposures at the site.

The analytical suite was limited to COIs identified in the SI; risks from exposure to organics at this site were not characterized in this HHRA. However, organics are not expected to be present at this site.

4.4.2 Exposure Assessment

Many of the factors used to estimate exposure rates at the site are standard assumptions based on EPA HHRA guidance values and may not accurately describe future site conditions or uses. The assumed receptors were limited to adult and child recreationalists. The recreational exposure frequencies are based on very limited use because of the remoteness of the site and the absence of nearby developed recreational areas. However, the assumed exposure duration of 30 years for the adult under the RME scenario may over estimate actual use since it is unlikely that a recreationalist will revisit the site for 30 consecutive years.

The anticipated recreational activities do not generally result in significant dermal contact or ingestion of sediment. Inclusion of these exposure pathways likely contributes additional conservatism to the HHRA. It is inherently assumed that future COPC concentrations will remain the same as current concentrations.

4.4.3 Toxicity Assessment

Uncertainties are inherent in toxicity factors because of several factors, including statistical extrapolation, population variability, and limited biological and epidemiological studies. These uncertainties may contribute to under or over estimation of potential risks and hazards.

4.4.4 Risk Characterization

The standard algorithms used to calculate the contaminant intakes and associated health risks and hazards add uncertainty to the risk assessment. The algorithms assume the additivity of toxic effects for multiple contaminants and do not account for synergistic or antagonistic effects. Concurrent exposure to multiple pathways by a single receptor and the associated cumulative risks and hazards also is assumed which likely over estimates actual exposures. The algorithms also do not account for factors such as absorption or matrix effects.

4.4.5 Lead Risk

Because of the lack of established quantitative reference data for lead, potential health risks from exposure to lead at the site were not quantified. However, the potential risks were qualitatively evaluated by comparing lead concentrations in mine waste and surface water samples to suggested screening values and may or may not be representative of actual risks. In addition, the EPA screening value (Region IX Industrial Soil PRG) is based on a worker scenario with 250 days of exposure. Therefore, application of this screening level should provide a very conservative estimate of lead risk at the Sunset Mine and Millsite where the adult recreationalist exposure is based on 14 days per year under the RME scenario.

4.5 Summary of Potential Human Health Risks

The estimated non-carcinogenic hazards and carcinogenic risks from exposure to COPCs at the Sunset Mine and Millsite are summarized in Table 11. The estimated non-carcinogenic hazards were compared to the EPA and Washington acceptable level of HI $\leq$ 1. The results indicate a non-carcinogenic hazard to the child recreationalist under the RME scenario, and no hazard to the adult recreationalist under both the CTE and RME scenarios. The total cumulative HI to the child recreationalist was < 1 under the CTE scenario, and 23 under the RME scenario. Incidental ingestion of copper (HI = 16) and arsenic (HI = 3), and dermal contact with arsenic (HI = 2) in the mine waste are the most significant exposure pathways.

The estimated carcinogenic risks from exposure to COPCs at the Sunset Mine and Millsite were compared with EPA's suggested screening ECR range of 1.E-06 to 1.E-04. The results indicate a low carcinogenic risk to the child recreationalist under the CTE scenario, and a moderate carcinogenic risk to both the child and adult recreationalist under the RME scenario. The total cumulative ECR to the child recreationalist was 4.E-06 under the CTE scenario, and 2.E-04 under the RME scenario. The total cumulative ECR to the adult recreationalist was 7.E-07 under the CTE scenario, and 4.E-05 under the RME scenario.

Incidental ingestion of and dermal contact with arsenic in the mine waste are the most significant exposure pathways and contribute the majority of carcinogenic risk at the site. Ingestion of arsenic in the surface water also contributed carcinogenic risk. Inhalation of particulates from the mine waste, and dermal contact with sediment and surface water contributed minimally to the overall risk and, therefore, are not considered to be significant exposure pathways at the site.

Human health risks resulting from exposure to lead at the site were not quantified because (1) the EPA has not established quantitative reference data for lead, and (2) the current lead exposure models are based on chronic long-term exposures and are not intended for assessing risk from occasional short-term exposures. However, the potential risks were qualitatively evaluated by comparing lead concentrations in mine waste, sediment, and surface water samples to establish suggested screening levels for the protection of human health.

The EPA has not specified a hazardous waste threshold value for total lead in soil and they have not established a drinking water maximum contaminant level (MCL) for lead; however, they suggest lead screening levels of 800 mg/kg for industrial soils and 15 µg/L for drinking water. The maximum detected lead concentration in mine waste at the site was 788 mg/kg, which is below the screening level. In sediment, the maximum detected lead concentration was only 10 mg/kg, well below the screening level. In surface water, lead was detected in only three samples and the MDC (2.8 µg/L), is well below the MCL. Therefore, there does not appear to be a human health risk from exposure to lead at the Sunset Mine and Millsite.

4.6 Hot Spot Assessment

Results of the HHRA indicate potential significant human health risks at the site from exposure to arsenic and copper in the mine waste and sediment; therefore, a hot spot assessment was conducted to identify specific areas contributing to a large percentage of the overall site risk. Hot spot concentrations for mine waste and sediment were back-calculated for each COPC using the HHRA risk equations based on an ECR of 1.E-04 and a non-cancer HI of 1.E+01 for the most sensitive receptor (child recreationalist). The hot spot concentrations are summarized in Table 12. Areas with COPC concentrations exceeding the hot spot concentrations are considered hot spots. A hot spot concentration was not calculated for lead because lead risks were qualitatively determined to be insignificant and not quantified.

Arsenic exceeded the hot spot concentration (410 mg/kg) in one mine waste sample (SM-WR7) from the southeast side of waste rock pile WR-2, and copper exceeded the hot spot concentration (365,730 mg/kg) in one mine waste sample from waste rock pile WR-5. Based on these results, waste rock piles WR-2 and WR-5 are considered to be hot spots. No sediment samples exceeded the hot spot concentrations.

4.7 Human Health Risk-based Cleanup Levels

Because results of the HHRA indicated potential significant human health risks at the site, risk-based cleanup levels were developed for the site. Cleanup levels were established for soil (mine waste) and sediment using an acceptable non-carcinogenic HI of 1.E+00 and a carcinogenic ECR of 1.E-05 for the most sensitive receptor (child recreationalist) under the RME scenario. The risk-based cleanup levels are summarized in Table 13.

Because lead risks were not quantified, a risk-based cleanup level could not be established. However, as discussed in Section 4.5, there does not appear to be a risk from exposure to lead at the site. In addition, the maximum detected lead concentration (788 mg/kg) at the site is well below the WDOE MTCA Method A Industrial Soil Cleanup Level of 1,000 mg/kg.

Cleanup levels for surface water typically default to state or federal water quality criteria, such as EPA MCLs; therefore, risk-based cleanup levels were not established. Although there appears to be low risk from ingestion of arsenic in surface water at the site, the maximum detected arsenic concentration in surface water (3.3 μg/L) is well below the EPA and Washington MCL of 10 μg/L.

Arsenic was above the cleanup level (41 mg/kg) in a total of 10 mine waste samples from five different areas, including soil south of the mill foundation, and waste rock piles WR-1, WR-2, WR-5, and WR-6. Antimony and copper concentrations were also above the calculated cleanup levels (252 mg/kg and 36,573 mg/kg, respectively) in one sample (SM-WR5-1) from waste rock pile WR-5.

5.0 STREAMLINED ECOLOGICAL RISK ASSESSMENT

A streamlined ecological risk assessment (ERA) was completed to assess potential risks to ecological receptors at the site from exposure to mine waste and contaminated media at the Sunset Mine and Millsite. The ERA was conducted in general accordance with state and federal regulations and guidelines, including:

- CERCLA;
- SARA;
- NCP 40CFR 300.415(b)(4)(i);

- EPA's *"Risk Assessment Guidance for Superfund Volume II – Environmental Evaluation Manual,"* 2001;
- EPA's *"Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund,"* 1997b;
- MTCA; and
- WAC 173-340.

The streamlined ERA consists of two levels:

Level 1 – Scoping ERA
- Identify the site ecological setting, sensitive environments, and T&E species
- Identify COIs
- Develop an ecological conceptual site exposure model (CSEM)

Level 2 – Screening ERA
- Identify potential ecological receptors and exposure pathways
- Identify assessment endpoints
- Estimate EPCs
- Screen contaminants of potential ecological concern (CPECs)
- Characterize ecological risks
- Evaluate uncertainties

The level 1 scoping ERA qualitatively determines whether there are potential ecological receptors or exposure pathways at the site and involves examining the ecological setting and identifying sensitive environments, T&E species, and ecological stressors. The level 2 screening ERA involves reviewing exposure pathways and receptors present at the site, determining assessment and measurement endpoints, identifying CPECs, calculating EPCs, characterizing ecological risks, and evaluating uncertainties associated with the ERA.

The following sections describe the streamlined ERA processes and results. Summary tables are provided at the end of the report and ecological risk screening and calculation tables are provided in Appendix B.

5.1 Level 1 Scoping Ecological Risk Assessment

The objective of the level 1 scoping ERA is to qualitatively determine whether there are any potential ecological receptors or exposure pathways at the site. It requires an examination of the ecological setting of the site, presence of sensitive environments, presence of T&E species, ecological stressors (i.e., COIs), and development of a CSEM. The level 1 scoping ERA consisted of three steps:

Step 1 – Identify ecological setting, sensitive environments, and T&E species

Step 2 – Identify COIs

Step 3 – Develop conceptual site ecological model

Each step is discussed in the following sections.

5.1.1 Ecological Setting, Sensitive Environments, and T&E Species

The SI was reviewed to identify the ecological setting of the site and determine whether any sensitive environments or species are present. The site is located in the Mount Baker-Snoqualmie National Forest within the Skykomish Ranger District in Snohomish County. Terrestrial habitats in vicinity of the site include mixed woodlands, riparian zones, and disturbed mine areas. The dominant upland and riparian overstory vegetation types on the hillsides and disturbed mine area include are *Tsuga heterophylla* (western hemlock), *Alnus rubra* (red alder), and *Acer circinatum* (vine maple). Dominant understory vegetation is dominated by *Berberis aquifolium* (Oregon grape), *Sambucus racemosa* (red elderberry), *Vaccinium parvifolium* (red huckleberry), and *Polystichum munitum* (sword fern). Riparian zone understory is dominated by *Salix sitchensis* (Sitka willow), *Rubus spectabilis* (salmonberry), *Oplopanax horridus* (Devil's club), and *Sambucus racemosa* (red elderberry) with many species composing the groundcover. Several edible plants occur on the site including salmonberry, huckleberry, trailing blackberry, red elderberry, and thimbleberry.

A detailed description of the hydrologic setting of the site is presented in the SI (CES 2005). The site is adjacent to Trout Creek, which flows into the North Fork Skykomish River (NFSR). An aquatic ecological survey of the site was conducted by CES and is detailed in the SI (2003).

Sensitive environments are defined in WAC 173-340-200, as "an area of particular environmental value, where a release could pose a greater threat than in other areas including: wetlands; critical habitat for endangered or threatened species; national or state wildlife refuge; critical habitat, breeding or feeding area for fish or shellfish; wild or scenic river; rookery; riparian area; big game winter range." Based on this definition, sensitive environments within 2 miles of the site include:

- Jurisdictional wetlands on Trout Creek, as summarized in the SI; and
- Threatened species and SOC that inhabit the Mt. Baker-Snoqualmie National Forest.

T&E species are those listed as threatened or endangered under the federal Endangered Species Act 16 U.S.C. Section 1533, or classified as threatened or endangered by the State Fish and Wildlife Commission under WAC 232-12-011(1) and 232-12-014. A list of T&E wildlife and plant species and species of concern (SOC) occurring in the Mt. Baker-Snoqualmie National Forest is provided in the SI (CES 2005). For the purposes of this ERA, a supplemental list of T&E and sensitive species was compiled based on information gathered from other sources, including the Endangered Species Program website (U.S. Fish and Wildlife Service 2006), Washington Department of Fish and Wildlife (2006), Pacific Biodiversity Institute (2006), and Washington Native Plant Society (2006). The list is provided in Appendix C and is intended to supplement information provided in the SI (CES 2005).

Although no threatened or endangered species were observed during the field investigation by CES, numerous federal and state rare, threatened, or endangered (RTE) mammals, birds, and herpetiles have potential habitat in vicinity of the site, including the Coho salmon, bull trout, Chinook salmon, Canadian lynx, spotted owl, Oregon spotted frog, western toad, willow flycatcher, Townsend's big-eared bat, fisher, and others. According to the ecological survey in the SI (CES 2005), none of the identified plants were RTE species and no RTE invertebrate species are known to inhabit the site vicinity. However, according to the Washington Native Plant Society, there are several T&E species that may be present on the site, including the *Arenaria paludicola* (marsh sandwort), *Castilleja levisecta* (golden paintbrush), *Howellia aquatilis* (water howellia), *Lupinus sulphureus ssp. kincaidii* (Kincaid's lupine), *Sidalcea nelsoniana* (Nelson's checker-mallow), and *Lomatium bradshawii* (Bradhsaw's desert parsley).

5.1.2 Contaminants of Interest

Identification of COIs for ecological receptors requires a separate process than the one used for the HHRA because while some contaminants may not present a risk to human health, they may pose an ecological risk. A preliminary list of COIs was identified based on analytical results presented in the SI and a potential risk to ecological receptors: aluminum, arsenic (III, V, and total), barium, beryllium, cadmium, chromium (III, VI and total), mercury, manganese, nickel, copper, lead, antimony, selenium, thallium, vanadium, silver, calcium, magnesium, iron, sodium, potassium, zinc, and cyanide. During the level 2 screening discussed in Section 5.2, COIs are examined further to identify contaminants of CPECs posing risk to ecological receptors at the site.

5.1.3 Ecological Conceptual Site Exposure Model

A CSEM illustrates the general understanding of the sources of contamination, release and transport mechanisms, impacted exposure media, potential exposure routes, and ecological receptors at the site. Like the human health CSM, the CSEM provides a framework for assessing risk by identifying the following:

- Environmental setting and contaminants known or suspected to exist at the site;
- Contaminant fate and transport mechanisms at the site;
- Mechanisms of toxicity associated with contaminants and potential receptors;
- Complete exposure pathways the site; and
- Potentially exposed populations.

The Sunset Mine CSEM, shown in Figure 2, was based on information provided in the SI and is intended to be representative of current and likely future conditions at the site. The primary source of CPECs is the waste rock piles. Precipitation could result in the following release/transport mechanisms from the waste rock piles: runoff, leaching, percolation, or infiltration into surface or subsurface soils, groundwater, or surface water. CPECs in the adit discharge can follow a similar pathway. Once in the surface water, CPECs can be deposited to sediment or transported downstream as a dissolved constituent, or attached to suspended sediment. Therefore, potential exposure media at the site includes waste rock, soil, sediment, pore water, and surface water.

Potential ecological receptors at the site include terrestrial wildlife (plants, birds, invertebrates, reptiles and amphibians, and mammals) and aquatic biota (fish and invertebrates). No RTE species were observed during the SI; however, bull trout (threatened-federal), Coho salmon (threatened-federal), Chinook salmon (threatened-federal), and rainbow trout (state priority species) have been documented in Trout Creek. In addition, based on the available data, there are multiple RTE species potentially present on site, in addition to SOC and Washington's listed species, including: spotted owl, Oregon spotted frog, Olive-sided flycatcher, willow flycatcher, coastal cutthroat, northern goshawk, western toad, and two varieties of bats.

5.2 Level 2 Screening Ecological Risk Assessment

The level 2 screening ERA involves evaluating data collected during the SI and identifying those contaminants and media that pose potential risks to ecological receptors at the site.

The level 2 screening consisted of six steps:

Step 1 – Summarizing the potential exposure pathways and receptors present on the site

Step 2 – Identifying assessment and measurement endpoints

Step 3 – Calculating EPCs

Step 4 – Identifying CPECs

Step 5 – Characterizing ecological risks

Step 6 – Evaluating uncertainties

Each of these steps is discussed below.

5.2.1 Potential Exposure Pathways and Receptors

Potential ecological exposure pathways at the site and evaluated in this ERA include:

- Incidental ingestion of soil (mine waste) and sediment;
- Direct contact with soil (mine waste), sediment, surface water, and pore water; and
- Ingestion of surface water.

Ingestion of plant species that tend to uptake metals from the soil and waste rock is another potential ecological exposure pathway at the site. However, according to the SI, vegetation is sparse on the waste rock piles and analytical results of plant tissue samples indicate that the concentration of metals in plants growing on the waste rock piles is generally similar to, or less than, background concentrations (CES 2005). In addition, the quantity of edible plant species in these areas is likely very limited and would only represent a small portion of a receptor's overall diet. Therefore, although potentially complete, ingestion of plant tissue was considered to be an insignificant pathway.

Potential ecological receptors at the site are expected to include terrestrial wildlife (plants, birds, invertebrates, reptiles and amphibians, and mammals) and aquatic biota (invertebrates and fish).

5.2.2 Ecological Endpoints

Identification of ecological endpoints guides the completion of the risk characterization portion of the ERA. Assessment and measurement endpoints for this ERA were developed based on the CSEM for the site. Assessment endpoints are defined by the EPA as "formal expression of an actual environmental value to be protected… an environmental value which would indicate a need for remediation." The assessment endpoints for this ERA included:

- Survival and reproductive success of terrestrial receptors (invertebrates, birds, mammals, and vegetation); and
- Survival and reproductive success of aquatic life (invertebrates and fish).

The measurement endpoint is defined by the EPA as a "quantitative expression of an observed or measured effects of a hazard; and, these measurable environmental characteristics are related to the valued characteristics chosen as assessment endpoints." Typically, the measurement endpoint will dictate

the type of samples and/or data to be collected and assessed to address the affect of stressors on the ecological receptors. However, because the data has already been collected, the measurement endpoint for this ERA consisted of:

- Comparison of the measured concentrations of the COIs in soil, waste rock, surface water, and sediment to their respective ecological risk-based screening level values (SLVs).

5.2.3 Exposure Point Concentrations

Ecological receptors do not experience their environment on a "point" basis; therefore, it is necessary to convert measured data from single sample points into an estimate of concentration over their habitat to conduct an appropriate risk screening. For this ERA, EPCs were based on either the MDC or UCL_{95} concentration from the analytical results presented in the SI, depending on the media and ecological receptor as suggested by ODEQ ecological risk assessment guidance (2001) and outlined below:

- For invertebrates (such as worms) and plants in mine waste, the MDC was used as the EPC, and
- For birds, aquatic life, and mammals, the UCL_{95} was used as the EPC in mine waste and surface water; the MDC was used in sediment and pore water because there were not enough samples to compute UCL_{95} concentrations.

5.2.4 Contaminants of Potential Ecological Concern

The COIs identified in the level 1 scoping ERA were screened through four processes to identify CPECs:

- Preliminary screening
- Chemistry-toxicity screening
- Bioaccumulation screening
- SLV availability screening

Preliminary Screening:
In accordance with EPA guidance (1998), the COIs identified in the level 1 scoping ERA were screened and removed from further analysis if they exhibited the following characteristics:

- Qualify as an essential nutrient;
- Were detected in fewer than 5 percent of the samples by media type; or
- Are present in concentrations below background concentrations.

With the exception of iron, the essential nutrients (calcium, magnesium, potassium, and sodium) were not present at concentrations above the SLVs; therefore, they were removed from further analysis. Iron was present in mine waste at concentrations well above the plant and invertebrate SLVs; therefore, iron was retained as a CPEC in mine waste.

COIs detected in fewer than 5 percent of the samples for each media type also were removed. All COIs were detected in more than 5 percent of the mine waste samples; however, in surface water, beryllium, cobalt, chromium, nickel, selenium, vanadium, and zinc were not detected in any samples. In sediment,

beryllium, mercury, selenium, and cyanide were not detected in any samples. In pore water, silver, aluminum, beryllium, cadmium, cobalt, chromium, iron, manganese, nickel, lead, antimony, selenium, thallium, vanadium, zinc, and cyanide were not detected in any samples.

The remaining COIs were screened against background levels. If the MDC was less than the average background concentration, the COI was removed from the risk analysis. As discussed in Section 2.0, background UCL_{95} concentrations were not calculated because fewer than four background samples were collected for each media. In mine waste, all COIs concentrations were above background levels. In surface water, only cadmium and thallium concentrations were below background levels. In sediment, silver, arsenic III, cadmium, and lead concentrations were below background levels. In pore water, the only detected COI below background levels was arsenic. The preliminary screening results are summarized in Tables 14 through 18.

Chemistry-toxicity Screening:

COIs remaining following the preliminary screening were subjected to chemistry-toxicity screening which involved assessing potential ecological risks by comparing the EPCs to ecological risk-based SLVs. When available, SLVs were obtained from WDOE MTCA (2001c, 2002, 2003a, 2003b); however, there were some instances where SLVs were not available in these documents. In such instances, SLVs were obtained from other sources such as the EPA, ODEQ, and ORNL.

A chemistry-toxicity screen was performed based on the following conditions:

- Exposure to a single COI in an exposure medium;
- Exposure to multiple COIs in an exposure medium; and
- Exposure to individual COIs in multiple exposure media.

Potential ecological risk from exposure to a single COI in an exposure medium was assessed by calculating contaminant-specific risk ratios (T_{ij}). Risk ratios for each COI were calculated using the following equation:

Single COI/single medium risk ratio: $$T_{ij} = \frac{C_{ij}}{SLV_{ij}}$$

Where:

T_{ij} = Risk ratio of COI i in medium j

C_{ij} = Contaminant concentration of COI i in medium j (milligram per kilogram [mg/kg] or mg/L)

SLV_{ij} = Screening level value for COI i in medium j (mg/kg or mg/L)

The risk ratios were compared to receptor-specific risk ratios (Q-factors) to evaluate potential ecological risk. In general, higher risk ratios present a greater likelihood that a CPEC concentration will adversely affect ecological receptors. Risk ratios greater than 1 ($Q > 1$) indicate potential risk for protected (i.e., federally and state listed T&E species) while risk ratios greater than 5 ($Q > 5$) indicate potential risk to non-protected receptors. It is expected that multiple T&E species, as well as candidate and SOC are potentially present on site. Therefore, a Q-factor of 1 was used in this streamlined ERA for mammals, birds, plants, and aquatic life; a Q-Factor of 5 was used for invertebrates since no threatened or endangered species were identified as being potentially present on site:

If $T_{ij} \geq Q$ retain COI *i* as a CPEC in medium *j*

Where:

T_{ij} = Risk ratio of COI *i* in medium *j*

Q = Receptor-specific risk ratio, = 5 for non-protected species (invertebrates), = 1 for protected species (birds, mammals, and aquatic life)

For exposure to multiple COIs in a single exposure medium, the potential ecological risk was assessed by calculating the ratio of a contaminant-specific risk ratio to the overall risk (sum of all contaminant-specific risk ratios) presented in a medium:

If $\frac{T_{ij}}{T_i} \geq \left(\frac{Q}{N_{ij}} \right)$ retain COI *i* as a CPEC in medium *j*

Where:

T_{ij} = Risk ratio of COI *i* in medium *j*

T_j = Sum of risk ratios (T_{ij}) from all COIs to each receptor group

Q = Receptor-specific risk ratio, = 5 for non-protected species (invertebrates), = 1 for protected species (birds, mammals, and aquatic life)

N_{ij} = Number of COIs with risk ratios (T_{ij}) for each receptor group

If a COI was detected in multiple media, it was retained as a CPEC if the sum of risk ratios exceeded the receptor-specific risk ratio:

If $\sum_{j=1}^{j} T_{ij} \geq Q$ retain COI *i* as a CPEC

Where:

T_{ij} = Risk ratio of COI *i* in medium *j*

Q = Receptor-specific risk ratio, = 5 for non-protected species (invertebrates), = 1 for protected species (birds, mammals, and aquatic life)

The results of the chemistry-toxicity screen are presented in the ecological risk calculation tables (Tables B.5 through B.8 in Appendix B), and summarized below according to exposure media. The screening results and identified CPECs are presented in Tables 14 through 18, and summarized in Table 19.

Mine Waste: Eighteen CPECs were identified in mine waste from single COI risk ratios: silver, aluminum, arsenic V, barium, cadmium, cobalt, chromium total, copper, iron, mercury, manganese, nickel, lead, antimony, selenium, thallium, vanadium, and zinc. Of these, aluminum, copper, and iron also pose risk to one or more receptors from multiple COI risk ratios. Three additional CPECs were retained because of the lack of SLVs: arsenic total, beryllium, and chromium VI.

Surface Water: Five CPECs were identified in surface water from single COI risk ratios: silver, aluminum, barium, copper, and lead. Of these, aluminum and copper also pose risk to one or more receptors from multiple COI risk ratios. Three additional CPECs were retained because of

the lack of SLVs: arsenic V, arsenic total, and antimony.

Sediment: Two CPECs were identified in sediment: copper and zinc. Eight additional CPECs were retained because of the lack of SLVs: aluminum, arsenic V, arsenic total, barium, cobalt, manganese, thallium, and vanadium.

Pore Water: No CPECs were identified in pore water from single or multiple COI risk ratios.

Multiple Media: Twelve CPECs were identified as posing to risk to birds or mammals from exposure to COIs in multiple media: aluminum, arsenic V, barium, copper, mercury, manganese, lead, antimony, selenium, thallium, vanadium, and zinc.

Bioaccumulation Screening:

COIs that are, or are suspected of being, persistent bioaccumulative toxins, such as mercury, require special attention. Bioaccumulative toxins can compromise food chains and induce adverse effects in higher trophic level species. COIs with bioaccumulative potential were retained as CPECs and include silver, cadmium, mercury, antimony, and iron. However, each of these COIs demonstrated risk to one or more ecological receptors in the chemistry-toxicity screening and, therefore, were already identified as CPECs.

SLV Availability Screening:

In some instances, SLVs were not available for a given COI-media-receptor combination. Because estimating the toxicity or bioaccumulative potential of the COI was not possible, the COI was retained as a potential CPEC. The COIs retained as CPECs because of the lack of SLVs are shown in Tables 14 through 19.

5.3 Ecological Risk Characterization

The results of the CPEC screening discussed above provide an approximate level of potential ecological risk at the site. Risk characterization is comprised of describing the risks to ecological receptors and the uncertainties in the ERA. The objective of the ecological risk description is to assess whether the predicted risks are likely to occur at the site. The objective of the uncertainties analysis is to examine the data gaps or sources of variability in the ERA process and whether these uncertainties under estimate or over estimate the ecological risks at the site. The uncertainty evaluation is described in Section 5.4 of this report.

The ecological risk ratio calculations are presented in Tables B.5 through B.9 in Appendix B, and the results are summarized in Table 20. The following sections discuss the ecological risk characterization for each media.

5.3.1 Mine Waste

Table B.5 in Appendix B presents the ecological risk calculations and results for mine waste. Aluminum and copper are the most significant CPECs because they pose a potential threat to all four ecological receptor groups (plants, invertebrates, birds, and mammals).

Eight CPECs pose a risk to mammals based on an acceptable risk ratio of $Q \leq 1$ for protected species: aluminum, arsenic V, barium, copper, antimony, selenium, thallium, and vanadium. The most significant risk to mammals is from copper (Q = 2,264), aluminum (Q = 209) and antimony (Q = 27). Aluminum and copper also pose a multiple COI risk to mammals. The remaining CPEC risk ratios are all less than 5.

Four additional potential CPECs were identified for mammals because of the lack of SLVs: silver, arsenic total, chromium total, and iron.

Eight CPECs pose a risk to birds based on an acceptable risk ratio of $Q \leq 1$ for protected species: aluminum, arsenic V, barium, copper, mercury, lead, selenium, and zinc. The highest risk to birds is from copper (Q = 4,069). There is also significant risk to birds from aluminum (Q = 50) and selenium (Q = 167). Copper also poses a multiple COI risk to birds. The remaining CPEC risk ratios were all less than 10. Eight additional potential CPECs were identified for birds because of the lack of SLVs: silver, arsenic total, beryllium, cobalt, chromium VI, iron, antimony, and thallium.

Seven CPECs pose a risk to invertebrates based on an acceptable risk ratio of $Q \leq 5$ for non-protected species: silver, aluminum, copper, iron, mercury, manganese, and zinc. The highest risks to invertebrates are from copper (Q = 17,660) and iron (Q = 1,130). There is also significant risk to invertebrates from exposure to aluminum (Q = 37), mercury (Q = 57), and manganese (Q = 14). Copper also poses a multiple COI risk to invertebrates. The remaining CPEC risk ratios were both less than 10. Six additional potential CPECs were identified for invertebrates because of the lack of SLVs: arsenic total, beryllium, chromium VI, antimony, thallium and vanadium.

Plants are the most sensitive receptor group with risk from 16 CPECs: silver, aluminum, arsenic V, cadmium, cobalt, chromium total, copper, iron, mercury, manganese, lead, antimony, selenium, thallium, vanadium, and zinc. The highest risk to plants is from iron (Q = 22,600), copper (Q = 8,830), aluminum (Q = 448), and silver (Q = 136). There is also significant risk from arsenic V (Q = 13), mercury (Q = 19), lead (Q = 16), antimony (Q = 80), selenium (Q = 50), vanadium (Q = 22), and zinc (Q = 13). Copper and iron also pose a multiple COI risk to plants. The remaining CPEC risk ratios are all less than 5.

5.3.2 Surface Water

Table B.6 in Appendix B presents the ecological risk calculations and results for surface water. Five CPECs were identified as posing a risk to aquatic life based on an acceptable risk ratio of $Q \leq 1$ for protected species: silver, aluminum, barium, copper, and lead. The highest risk is from exposure to copper (Q = 42). Copper also posed a multiple COI risk to aquatic life. Risk ratios for the remaining CPECs were all less than 5.

No CPECs were identified in surface water as posing a risk to birds or mammals from single COI risk ratios; however, under risk from multiple COIs, aluminum poses a risk to both receptors and copper poses a risk to birds. Silver and arsenic (V and total) were retained as potential bird and mammal CPECs because of the lack of SLVs; antimony was retained as potential aquatic life and bird CPEC because of the lack of SLVs.

5.3.3 Sediment

Table B.7 in Appendix B presents the ecological risk calculations and results for sediment. Two CPECs were identified as posing a risk to aquatic life based on an acceptable risk ratio of $Q \leq 1$ for protected species: copper and zinc. The highest risk is from bioaccumulation of zinc (Q = 31) and copper (Q = 11). The only CPEC that poses a freshwater sediment risk is copper (Q = 1.4).

Aluminum, arsenic (V and total), barium, cobalt, manganese, thallium, and vanadium were retained as potential aquatic life CPECs because of the lack of SLVs.

5.3.4 Pore Water

Table B.8 in Appendix B presents the ecological risk calculations and results for pore water. No CPECs were identified in pore water from exposure to single or multiple COIs based on an acceptable risk ratio of $Q \leq 1$ for protected species.

5.4 Uncertainty Evaluation

There are several sources of potential uncertainty associated with this ERA. These sources and their potential impact on the prediction of potential risks to ecological receptors at the site are discussed in the following sections.

5.4.1 Sample Data

The selection of sampling media, sample locations, quantity of samples, sampling procedures, and sample analysis introduce some uncertainties into this ERA. For example, time and monetary restraints limit the number of samples that can be collected; therefore, sample locations are selected based on knowledge of anticipated presence of particular contaminants. Overall, the data used in this ERA were generally collected from areas with expected elevated metals concentrations. As a result, this assessment likely over estimates the risk posed to ecological receptors at the site.

The lack of established SLVs for several COIs were another source of uncertainty in the ERA. COIs retained as CPECs because of the lack of SLVs rather than because of high-risk ratios may result in an over estimation of the overall potential for ecological risk at the site.

5.4.2 Screening Level Values

"NOAEL" is the acronym used for "No Observed Adverse Effect Level." It means the highest exposure level at which there are no statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control; some effects may be produced at this level, but they are not considered to be adverse, nor precursors to specific adverse effects (WAC 173-340-200).

"LOAEL" is the acronym used for "Lowest Observed Adverse Effect Level" which means the lowest concentration of a hazardous substance at which there is a statistically or biologically significant increase in the frequency or severity of an adverse effect between an exposed population and a control group (WAC 173-340-200).

The ecological risk-based SLVs used in this ERA are intended to be NOAELs, with the exception of sediment SLVs. Ecological effects occur at some concentration between the NOAELs and the LOAELs; therefore, concentrations exceeding the SLV do not necessarily constitute a "real" risk for ecological receptors. Thus, use of NOAEL-based SLVs results in an over estimation of actual ecological risks at the site.

5.4.3 CPEC Selection

The CPEC background concentration screening for pore water and sediment was based on only one background sample. Concentrations of COIs, particularly metals, are naturally variable; therefore, a single sample does not accurately reflect "natural" conditions. As a result, improper inclusion of contaminants during the background screening may result in over estimating actual risks, and improper

exclusion of contaminants may result in under estimating actual risks. In addition, the use of the MDC or UCL_{95} as the EPC may inherently introduce conservatism and contribute to over estimation of risk at the site.

5.4.4 Home Range

The use of SLVs assumes that the receptor's habitat is restricted to the affected area represented by the EPC. However, these areas typically offer lower habitat quality compared to adjoining habitat and it is unlikely that a receptor would limit its habitat strictly to these areas. Also, the home range for most birds and mammals covers a fairly large area. Therefore, because of the relatively small area of the waste rock piles, the use of SLVs likely over estimates actual risk.

5.5 Summary of Potential Ecological Risks

Results of the streamlined ERA indicate very high ecological risk rations and significant potential risk to ecological receptors at the Sunset Mine and Millsite. However, generally these risks appear to be limited to individual receptors and there does not appear to be significant population-level risks. While individual receptors may be at risk from exposure to CPECs at the site, their populations are unlikely to be significantly impacted in the vicinity of the mine because it is unlikely that entire populations would reside entirely within the contaminated areas of the site. These areas typically offer lower habitat quality compared to adjoining habitat; therefore, it is unlikely that a receptor would limit its habitat strictly to these areas. In addition, birds and mammals have a relatively large home range and the contaminated areas of the site probably represent a very small percentage of the overall home range. While there are some sensitive amphibian and fish species, such as the Oregon tailed frog and western toad, that have relatively small home ranges and my inhabit the seep areas, the site represents a very small percentage of available habitat in this area and, as such, is unlikely to cause any population level effects. Fish species such as Chinook and Coho salmon also may inhabit Trout Creek during their spawning and rearing cycles, where juvenile and eggs may be vulnerable to exposure from CPECs from these contaminated areas.

Although there is no evidence of T&E species inhabiting the site and none were observed during the SI, available data from the USFS and FWS identify known and potential T&E habitats within the Mt. Baker-Snoqualmie National Forest. Therefore, these species may inhabit the area and occasionally traverse the site. Sensitive species such as the Oregon tailed frog (federal candidate species) and western toad (federal SOC) will be sensitive to metals in both the sediment and surface water. In addition, the range of these species is not as broad as other species potentially present. Other species, such as the spotted owl (threatened) and the northern goshawk (federal SOC), may also be affected through surface water, and indirectly through soil consumption via predation.

6.0 CONCLUSIONS

Results of the streamlined RAs indicate significant potential risks to both human and ecological receptors at the site. The HHRA indicates non-carcinogenic hazard and carcinogenic risk from exposure to metals in the mine waste at the site, particularly arsenic and copper. Ingestion of surface water also poses a low carcinogenic human health risk to the adult receptor. Eight human health COPCs were identified: antimony, arsenic, cadmium, chromium, copper, iron, lead and mercury. The most significant exposure pathway is ingestion of and dermal contact with the mine waste. Inhalation of particulates from the mine waste, and dermal contact with sediment and surface water contribute minimal risk and are insignificant pathways.

Results of the streamlined ERA indicate significant potential risk to ecological receptors at the site; however, the risks appear to be limited to individual receptors rather than whole populations. This is because (1) the home range for most receptors is significantly larger than the site and it is improbable that entire populations of receptors reside strictly within the site boundaries, and (2) the site likely represents suboptimal habitat compared to the surrounding area. However, for some individuals, particularly amphibians such as the Oregon tailed frog or western toad, the site may constitute their entire home range. This is critical because T&E species are to be protected to the individual level. Several CPECs were identified and the highest risk ratios for all terrestrial and avian receptors are from exposure to metals in the mine waste, particularly aluminum, arsenic, copper, iron, mercury, antimony, and selenium. There is also potential risk to aquatic receptors such as Chinook salmon and bull trout from exposure to metals concentrations (especially copper) in surface water and sediment at the site.

A hot spot assessment was completed and human health risk-based cleanup criteria were back calculated using the human health EFs and risk equations. Soil and sediment hot spot concentrations were calculated for all COPCs based on the most sensitive receptor (child recreationalist) under the RME scenario, a hot spot carcinogenic risk level of 1.E-04 for total cumulative risk, and a non-carcinogenic HI of 10. No COPCs exceeded the sediment hot spot concentrations, and only arsenic and copper exceeded the soil hot spot concentrations of 410 mg/kg and 365,730 mg/kg, respectively. Two locations were identified as hot spots based on arsenic and copper concentrations in the mine waste samples: (1) waste rock pile WR-2 (arsenic = 410 mg/kg), and (2) waste rock pile WR-5 (copper = 883,000 mg/kg).

Human health risk-based cleanup levels were also calculated for all COPCs in soil and sediment based on the most sensitive receptor (child recreationalist) under the RME scenario, an acceptable multiple-COI carcinogenic risk level of 1.E-05 for total cumulative risk, and a non-carcinogenic HI of 1. While these cleanup levels are intended to be protective of human health, they will likely be protective of ecological receptors as well because the areas containing the highest arsenic and copper concentrations generally also contain the highest concentrations of the other COPCs and CPECs. No COPCs exceeded the sediment cleanup levels and only antimony, arsenic, and copper exceeded the soil cleanup levels. Arsenic concentrations in soil samples from five areas exceeded the cleanup level of 41 mg/kg: (1) soil south of the mill foundation (50 to 60 mg/kg), (2) waste rock pile WR-1 (49 to 60 mg/kg), (3) waste rock pile WR-2 (110 to 1,150 mg/kg), (4) waste rock pile WR-5 (133 mg/kg), and (5) waste rock pile WR-6 (63 mg/kg). Antimony and copper concentrations exceeded the cleanup levels of 252 mg/kg and 36,573 mg/kg, respectively, in only one soil sample from waste rock pile WR-5 (antimony = 400 mg/kg and copper = 883,000 mg/kg).

Removal of waste rock and soil from the areas with arsenic and copper concentrations exceeding the cleanup levels should significantly reduce both the overall human health and potential ecological risk at the site. The total volume of waste rock in the four waste rock piles exceeding cleanup levels was estimated in the SI to be about 1,110 cyd. Removal of the waste rock should also improve surface water quality in Trout Creek by significantly reducing metals migration to the stream from sheetflow and erosion of the waste rock piles. However, the adit discharges, particularly from Adit 2, will continue to contribute metals loading to Trout Creek and pose a risk to human and ecological receptors.

Based on the results of the streamlined RAs, MSE recommends performing a streamlined Engineering Evaluation/Cost Analysis (EE/CA) to address metals concentrations in the mine waste, soil, sediment, and surface water at the site.

DISCLAIMER

This abandoned mine/mill site was created under the General Mining Law of 1872 and is located solely on National Forest System (NFS) lands administered by the USFS. The United States has taken the position and courts have held that the United States is not liable as an "owner" under CERCLA Section 107 for mine contamination left behind on NFS lands by miners operating under the 1872 mining law. Therefore, USFS believes that this site should not be considered a "federal facility" within the meaning of CERCLA Section 120 and should not be listed on the Federal Agency Hazardous Waste Compliance Docket. Instead, this site should be included on EPA's CERCLIS database Consistent with the June 24, 2003 OECA/FFEO "Policy on Listing Mixed Ownership Mine or Mill Sited Created as a Result of the General Mining Law of 1872 on the Federal Agency Hazardous Waste Compliance Docket," we respectfully request that the EPA Regional Docket Coordinator consult with the USFS and EPA Headquarters before making a determination to include this site on the Federal Agency Hazardous Waste Compliance Docket.

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EXPIRES 9-27-07

R1670

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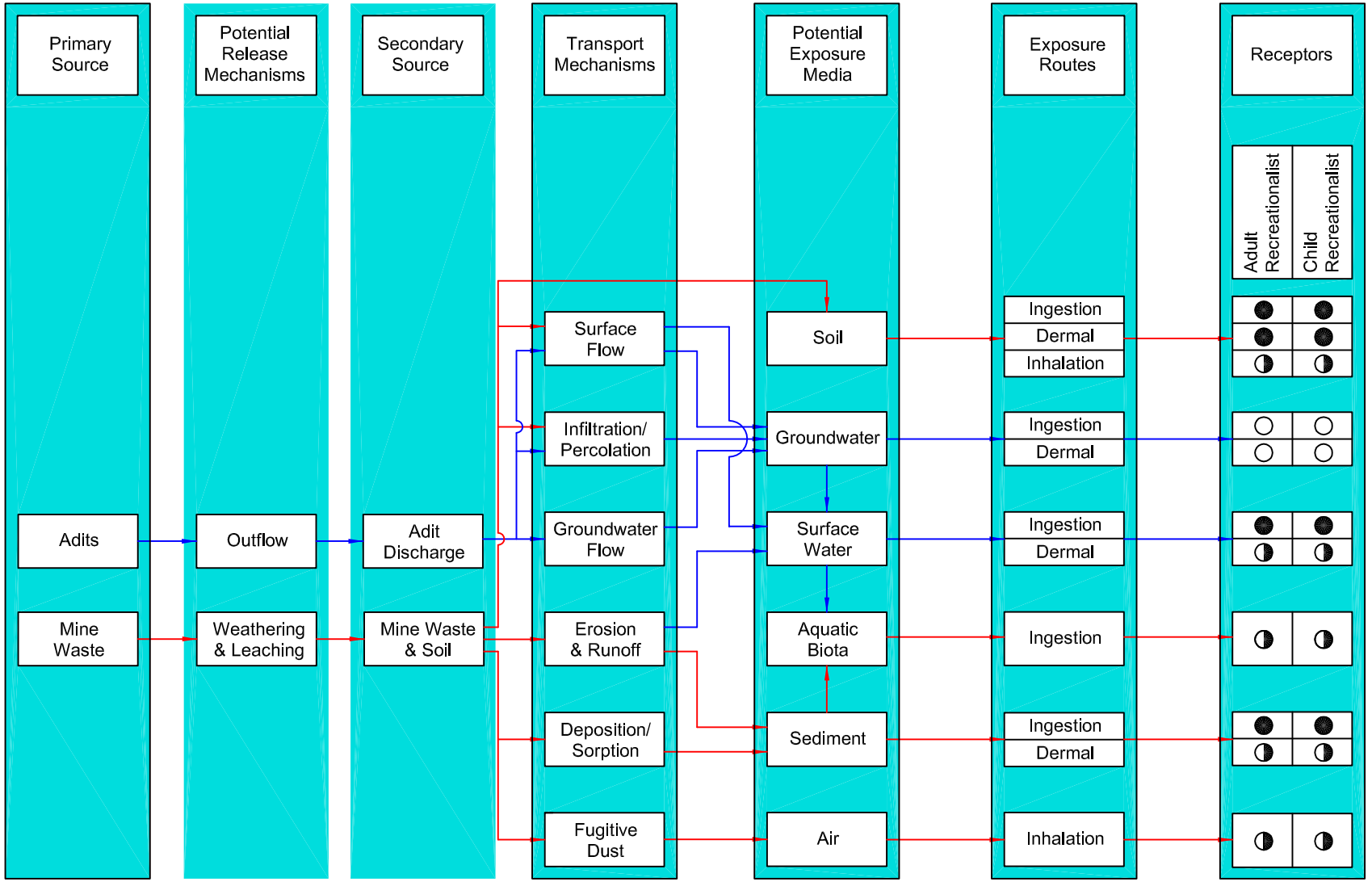
FIGURES



Legend

- ● Complete and potentially significant exposure pathway
- ◑ Potentially complete but insignificant exposure pathway
- ○ Incomplete exposure pathway

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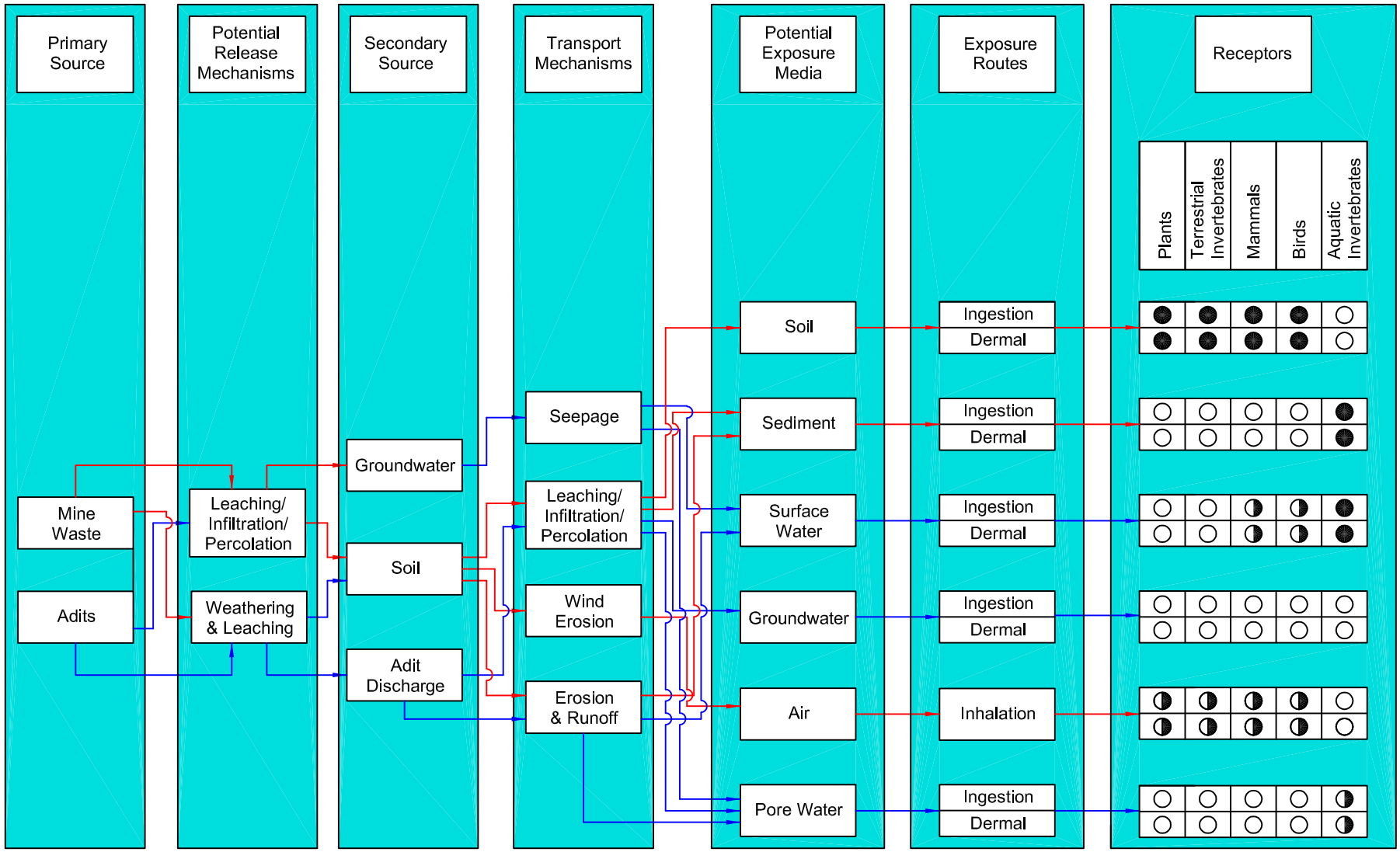
Human Health Conceptual Site Model

B2473D	4/10/06	HH CSM.dwg	FIGURE 1



Legend

- ● Complete and potentially significant exposure pathway
- ◑ Potentially complete but insignificant exposure pathway
- ○ Incomplete exposure pathway

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Ecological Conceptual Site Exposure Model

B2473D	4-10-06	ERA CSM.dwg	FIGURE 2

TABLES

TABLE 1
Estimated Mine Waste Volumes
Sunset Mine and Millsite

Waste Rock Pile	Estimated Volume[a] (cubic yards)
WR-1	300
WR-2	10
WR-3	800
WR-4	60
WR-5	300
WR-6	500
Total Volume =	**1970**

Notes:
[a]Source: Sunset Mine and Millsite Site Inspection (CES 2005)

TABLE 2
Mine Waste Analytical Results Summary
Sunset Mine and Millsite

Sample ID	pH	Analyte Concentration (mg/kg)																										
		Ca	K	Mg	Na	CN	Ag	Al	As_3	As_5	As_T	Ba	Be	Cd	Co	Cr_3	Cr_6	Cr_T	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
SM-S1	5.6	1590	1380	5790	100	NA	24	10600	**0.502**	59.5	60	20.1	0.1	2.5	10	NA	0.429	12	16500	35700	0.22	506	20	72	5	25	1.5	24.1	100
SM-S2	6.6	1990	1020	4850	140	NA	1.8	8220	NA	NA	9	40.5	0.1	0.5	7	NA	NA	13	2420	19200	0.025	319	12	18	1	5	0.3	26.1	60
SM-S3	6.0	2410	1690	5050	120	NA	47	11400	0.4	24.8	50	43.7	0.1	5	10	NA	103.6	13	24500	40000	0.27	517	10	130	10	50	2.5	27.1	100
SM-WR1-1	7.4	10500	1840	7260	100	NA	18	14700	0.376	24.8	50	68	0.1	5	16.0	NA	6.029	19	28100	54708	1.06	970	10	140	10	50	2.5	30.7	100
SM-WR2-1	3.5	400	1720	5500	90	NA	125	11300	NA	NA	280	36.7	0.5	2.5	9	NA	NA	19	6680	16700	2.34	380	5	131	10	25	1.5	41	50
SM-WR2-2	2.9	900	1840	5000	**210**	NA	40	10800	0.2	109.8	110	67.8	0.5	1.5	10	NA	0.53	21	6070	94500	0.95	312	12	57	2.5	15	0.5	37	25
SM-WR3-1	6.2	3620	2010	5250	30	NA	6	18600	NA	NA	30	27.6	0.3	2.5	16	NA	NA	7	5520	46200	0.58	1190	5	16	5	25	1.5	16.2	200
SM-WR3-2	7.2	5130	1890	4110	30	NA	1.7	15100	0.139	2.45	5	30.7	0.2	0.5	13	NA	0.405	7	2740	38500	1.34	1070	3	3	1	5	0.25	13.4	70
SM-WR3-3	7.1	4040	1920	6860	130	NA	0.015	12400	NA	NA	0.15	63.4	0.2	0.025	12	NA	NA	13	6240	37800	0.7	738	0.0	0.11	2.5	0.25	0.13	29.8	0.5
SM-WR4	5.7	3910	1370	**9250**	60	NA	6.3	**22400**	0.3	40.7	41	31.7	0.4	0.8	21	NA	25.9	19	18500	61600	0.63	**1400**	23	248	4	1	0.3	**44.5**	189
SM-WR5-1	7.3	**13400**	2300	1900	30	NA	11.3	6200	0.3	**132.7**	133	16.1	1	1.6	26	NA	0.408	7	**883000**	84000	0.44	884	20	84.2	400	3	0.22	17	152
SM-WR6-1	5.3	1650	2250	7900	110	NA	3.31	18200	0.151	27.2	27.4	26.7	0.3	0.3	21	NA	0.3805	16	10500	43800	0.4	966	30	14.2	5	0.5	0.22	35.9	94
SM-WR6-2	3.3	100	1430	1400	40	NA	7.36	4170	NA	NA	62.8	8.4	1	0.37	2.5	NA	NA	5	6280	94000	1.41	92	6	29.0	7	1.9	0.14	8	30
SM-WR6-3	5.9	1820	1840	6060	90	NA	6.71	15500	NA	NA	28.5	31.0	0.2	0.6	16	NA	NA	14	12100	40000	0.28	708	20	14.8	5	0.25	0.18	29.2	79
SM-WR7	3.8	900	1380	1700	70	NA	**268**	5630	NA	NA	**1150**	**111**	1	0.7	8	NA	NA	**59**	10500	**226000**	**5.74**	442	30	788	20	20	0.25	19	151
SM-WR8	6.0	1870	2390	5900	100	NA	24.0	14300	0.236	49.1	49.3	41.9	0.2	0.91	11	NA	0.558	18	30900	40300	0.41	646	5	122	10	2.9	0.18	33.4	**1078**
SM-WR9	5.5	2400	**2530**	5300	60	NA	40	11600	NA	NA	59.7	82.1	1	1.0	11	NA	84.79	13	3800	60000	0.17	634	20	512	20	3	0.15	22	128
minimum =	2.9	100	1020	1400	30	NA	0.015	4170	0.14	2.45	0.15	8.4	0.1	0.025	2.5	NA	0.38	5	2420	16700	0.025	92	0.0	0.11	1	0.25	0.13	8	0.5
MDC =	**7.4**	**13400**	**2530**	**9250**	**210**	**NA**	**268**	**22400**	**0.5**	**132.7**	**1150**	**111**	**1**	**5**	**26**	**NA**	**103.6**	**59**	**883000**	**226000**	**5.74**	**1400**	**30**	**788**	**400**	**50**	**2.5**	**44.5**	**1078**
average =	5.6	3331	1812	5240	89	NA	37.1	12419	0.3	52	126	44.0	0.42	1.55	12.9	NA	22.30	16	63197	60765	1.00	693	13.6	140.0	30.5	13.7	0.72	27	153
95% UCL =		**5278**	**1986**	**6134**	**109**	**NA**	**83.4**	**14472**	**0.4**	**78.8**	**782**	**55.2**	**0.6**	**2.6**	**15.4**	**NA**	**145**	**21**	**584395**	**80999**	**1.7**	**841**	**17.5**	**280**	**261**	**26.2**	**2.7**	**31.0**	**265**
Freq detected =		100%	100%	100%	100%	**NA**	94%	100%	100%	100%	94%	100%	35%	47%	94%	**NA**	40%	100%	100%	100%	94%	100%	53%	100%	18%	29%	53%	100%	71%
Human Health Screening Criteria																													
WDOE MTCA Method A Industrial Soil Cleanup Levels – Human Receptors (WDOE 2001b)		NS	NS	NS	NS	20	NS	NS	2	NS	2000	19	19	NS	NS	2	NS	NS	1000	NS	NS	NS	NS	NS				
EPA Region IX Industrial Soil PRGs (EPA 2004a)		5100	100000	NS	NS	1.6	67000	1900	450	1900	100000	30	450	41000	100000	310	19000	20000	800	410	5100	67	1000	100000				
Ecological Screening Criteria																													
WDOE MTCA Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals (WDOE 2001c)		2	50	7	10	NS	102	10	4	20	NS	NS	42	50	NS	0.1	1100	30	50	5	0.3	1	2	86				
EPA Ecological Soil Screening Levels (Eco-SSLs) (EPA 2005b)		NS	NS	NS	NS	18	330	21	0.36	13	26	81	NS	NS	NS	NS	NS	NS	11	0.27	NS	NS	7.8	NS				
ORNL Soil PRGS for Ecological Endpoints (Efroymson et al. 1997)		2	NS	NS	NS	9.9	283	10	4	20	NS	NS	0.4	60	NS	0.00051	NS	30	40.5	5	0.21	1	2	8.5				

Notes:

Result below method detection limit, reported at 1/2 reporting limit

Result between method detection limit and practical quantitation limit, reported at detected concentration

Calculated value

Ecological screening criteria exceeded

Human health screening criteria exceeded

EPA = U.S. Environmental Protection Agency
MDC = Maximum detected concentration
MTCA = Model Toxics Control Act
NA = Not analyzed for
NS = No standard
ORNL = Oak Ridge National Laboratory
PRG = Preliminary remediation goal
WDOE = Washington Department of Ecology
mg/kg = Milligram per kilogram

TABLE 3
Background Soil Analytical Results Summary
Sunset Mine and Millsite

Sample ID	pH	Analyte Concentration (mg/kg)																								
		Ca	K	Mg	Na	Ag	Al	As_3	As_5	As_T	Ba	Be	Cd	Co	Cr_3	Cr_6	Cr_T	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
SM-BGS-1	5	1530	405	2830	130	0.73	15400	0.024	12.35	12.4	52.1	0.2	0.4	5	14.91	0.544	16	291	15500	0.06	142	11.8	7.5	0.1	0.5	0.025	38	114
SM-BGS-2	5.5	2490	720	6650	170	0.11	16900	0.062	7.54	7.6	143	0.1	0.52	10	16.04	0.482	17	121	18800	0.02	247	18.1	5.62	0.1	0.25	0.015	43.4	126
SM-BGS-3	5.3	2840	350	3140	160	0.3	11600	0.049	12.95	13	53.6	0.1	0.7	6	9.93	0.536	11	631	13700	0.1	341	9	13.1	0.5	2.5	0.15	31.7	70
minimum =	5	1530	350	2830	130	0.11	11600	0.024	7.54	7.6	52.1	0.1	0.4	5	9.9	0.482	11	121	13700	0.02	142	9	5.6	0.1	0.25	0.02	31.7	70
MDC =	**5.5**	**2840**	**720**	**6650**	**170**	**0.73**	**16900**	**0.062**	**12.95**	**13**	**143**	**0.2**	**0.7**	**10**	**16.0**	**0.544**	**17**	**631**	**18800**	**0.10**	**341**	**18.1**	**13.1**	**0.5**	**2.50**	**0.15**	**43.4**	**126**
average[a] =	5.3	2287	492	4207	153	0.63	14633	0.045	10.9	11.0	82.9	0.1	0.54	7	13.6	0.521	14.7	348	16000	0.06	243	13.0	8.7	0.2	1.08	0.06	37.7	103.3
Freq detected =		100%	100%	100%	100%	100%	100%	67%	100%	100%	100%	33%	100%	100%	100%	0%	100%	100%	100%	67%	100%	100%	100%	33%	0%	0%	100%	100%
Human Health Screening Criteria																												
WDOE MTCA Method A Industrial Soil Cleanup Levels – Human Receptors (WDOE 2001b)		NS	NS	NS	NS	20	NS	NS	2	NS	2000	19	19	NS	NS	2	NS	NS	1000	NS	NS	NS	NS	NS			
EPA Region IX Industrial Soil PRGs (EPA 2004a)		5100	100000	NS	NS	1.6	67000	1900	450	1900	100000	30	450	41000	100000	310	19000	20000	800	410	5100	67	1000	100000			
Ecological Screening Criteria																												
WDOE MTCA Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals (WDOE 2001c)		2	50	7	10	NS	102	10	4	20	NS	NS	42	50	NS	0.1	1100	30	50	5	0.3	1	2	86			
EPA Ecological Soil Screening Levels (Eco-SSLs) (EPA 2005b)		NS	NS	NS	NS	18	330	21	0.36	13	26	81	NS	NS	NS	NS	NS	NS	11	0.27	NS	NS	7.8	NS			
ORNL Soil PRGS for Ecological Endpoints (Efroymson et al. 1997)		2	NS	NS	NS	9.9	283	10	4	20	NS	NS	0.4	60	NS	0.00051	NS	30	40.5	5	0.21	1	2	8.5			

Notes:

Result below method detection limit, reported at 1/2 reporting limit

Result between method detection limit and practical quantitation limit, reported at detected concentration

Calculated value

Ecological screening criteria exceeded

Human health screening criteria exceeded

[a]95 Percent upper confidence levels not computed because fewer than four samples.

EPA = U.S. Environmental Protection Agency

MDC = Maximum detected concentration

MTCA = Model Toxics Control Act

NS = No standard

ORNL = Oak Ridge National Laboratory

PRG = Preliminary remediation goal

WDOE = Washington Department of Ecology

mg/kg = Milligram per kilogram

TABLE 4
Surface Water Analytical Results Summary
Sunset Mine and Millsite

Sample ID	Analyte Concentration (ug/L)[a]																						
	Ag	Al	As_3	As_5	As_T	Ba	Be	Cd	Co	Cr_3	Cr_6	Cr_T	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
TC-SW1 (background)	0.05	50	0.059	0.2	0.2	3	1	0.1	5	5	0.5	5	0.5	20	0.00046	2.5	5	0.4	0.2	0.1	0.4	2.5	5
minimum =	0.05	50	0.059	0.2	0.2	3	1	0.1	5	5	0.5	5	0.5	20	0.00046	2.5	5	0.4	0.2	0.1	0.4	2.5	5
MDC =	**0.05**	**50**	**0.059**	**0.2**	**0.2**	**3**	**1**	**0.1**	**5**	**5**	**0.5**	**5**	**0.5**	**20**	**0.00046**	**2.5**	**5**	**0.4**	**0.2**	**0.1**	**0.4**	**2.5**	**5**
average =	0.05	50	0.059	0.2	0.2	3	1	0.1	5	5	0.5	5	0.5	20	0.00046	2.5	5	0.4	0.2	0.1	0.4	2.5	5
NFSR[c]:																							
NFSR-SW1	0.05	40	0.083	0.62	0.7	5	1	0.05	5	5	0.5	5	0.5	30	0.00043	2.5	5	0.05	0.1	0.05	0.05	2.5	5
NFSR-SW2	0.05	50	0.081	0.62	0.7	5	1	0.05	5	5	0.5	5	0.5	20	0.00041	2.5	5	0.05	0.1	0.05	0.2	2.5	5
Site:																							
TC-SW2	0.05	40	0.066	0.1	0.2	3	1	0.05	5	5	0.5	5	1	5	0.00037	2.5	5	0.1	0.1	0.05	0.05	2.5	5
TC-SW3	0.05	30	0.083	0.1	0.2	3	1	0.05	5	5	0.5	5	0.8	10	0.00043	2.5	5	0.05	0.1	0.05	0.05	2.5	5
SM-AS1	0.025	50	0.0035	0.7	0.7	11	1	0.1	5	5	0.5	5	126	5	0.00384	2.5	5	0.05	2.4	0.5	0.025	2.5	5
SM-AS2-1	0.07	30	0.03	3.1	3.1	18	1	0.1	5	5	0.5	5	90.7	10	0.00391	2.5	5	0.05	0.5	0.5	0.025	2.5	5
SM-AS2-2	0.26	**270**	**0.131**	3.2	**3.3**	**20**	1	0.1	5	5	0.5	5	**212**	**380**	**0.00604**	13	5	**2.8**	0.6	0.5	0.025	2.5	5
min (excluding BG) =	0.025	30	0.0035	0.1	0.2	3	1	0.05	5	5	0.5	5	0.8	5	0.00037	2.5	5	0.05	0.1	0.05	0.025	2.5	5
MDC (excluding BG) =	**0.26**	**270**	**0.131**	**3.2**	**3.3**	**20**	**1**	**0.1**	**5**	**5**	**0.5**	**5**	**212**	**380**	**0.00604**	**13**	**5**	**2.8**	**2.4**	**0.5**	**0.05**	**2.5**	**5**
avg (excluding BG) =	0.09	84.00	0.06	1.43	1.50	11	1	0.08	5	5	0.5	5	86.10	82.00	0.0029	4.60	5	0.61	0.74	0.32	0.04	2.5	5
95% UCL =	**0.27**	**278**	**0.11**	**2.95**	**2.99**	**18.7**	**1**	**0.11**	**5**	**5**	**0.5**	**5**	**171**	**823**	**0.0053**	**13.8**	**5**	**6.1**	**3.38**	**1.42**	**0.05**	**2.5**	**5**
Freq detected =	25%	100%	88%	63%	88%	88%	0%	38%	0%	0%	0%	0%	75%	75%	100%	13%	0%	38%	38%	0%	25%	0%	0%
Human Health Screening Criteria																							
1a - Wash HH	NS	NS	NS	NS	0.018	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.14	NS	610	NS	14	170	1.7	NS	NS
1b - Wash HH	100	NS	NS	NS	10	2000	4	5	NS	NS	NS	100	1300	300	2	50	100	15	6	50	2	NS	5000
2- EPA HH	NS	NS	NS	NS	0.018	1000	NS	NS	NS	NS	NS	NS	1300	300	NS	50	610	NS	5.6	170	0.24	NS	7400
Ecological Screening Criteria																							
3- Wash Eco[b]	NS	NS	NS	NS	190	NS	NS	0.42	NS	63.7	10.4	NS	4.05	NS	0.012	NS	54.5	0.64	NS	5	NS	NS	36.6
4- EPA Eco[b]	0.36	NS	NS	3.1	150d	4	0.66	0.10	23	27	11d	NS	3	1000	0.77d	120	18	0.63	30	5	12	20	41
5 -ORNL Eco	0.36	87	0.19	0.0031	3.1	4	0.66	0.00015	23	NS	0.002	2	0.23	158	0.23	120	160	0.66	30	0.39	9	20	30

Sample ID	pH	Analyte Concentration (ug/L)[a]					
		Ca	Hard	K	Mg	Na	Sulfate
TC-SW1 (background)	6.8	1800	6	150	300	700	5
minimum =	6.8	1800	6	150	300	700	5
maximum =	**6.8**	**1800**	**6**	**150**	**300**	**700**	**5**
average =	6.8	1800	6	150	300	700	5
NFSR[c]:							
NFSR-SW1	7.0	3100	10	400	500	1600	5
NFSR-SW2	7.0	2500	8	300	500	1300	5
Site:							
TC-SW2	6.8	1800	6	150	300	600	5
TC-SW3	6.8	1800	6	150	300	600	5
SM-AS1	7.3	9800	29	400	1000	1400	10
SM-AS2-1	7.6	20400	61	700	2500	2800	20
SM-AS2-2	7.6	20300	61	800	2600	2700	20
min (excluding BG) =	6.8	1800	6	150	300	600	5
MDC (excluding BG) =	**7.6**	**20400**	**61**	**800**	**2600**	**2800**	**20**
avg (excluding BG) =	7.2	10820	32.6	440.0	1340	1620	12.0
95% UCL =		**19679**		**729**	**2428**	**2652**	
Freq detected =		100%		63%	100%	100%	38%

Notes:

Result below method detection limit, reported at 1/2 reporting limit

Result between method detection limit and practical quantitation limit, reported at detected concentration

Calculated value

Ecological screening criteria exceeded

Human health screening criteria exceeded

[a]Total concentrations

[b]Screening criteria for hardness dependent metals are based on a average hardness of 28.5 and were converted to total concentrations where applicable.

[c]Samples from NF Skykomish River were not included with samples from the site in determining minimum, maximum, and average concentrations.

BG = Background
EPA = U.S. Environmental Protection Agency
MDC = Maximum detected concentration
min = Minimum
NFSR = North Fork Skykomish River
NOAA = National Oceanic and Atmospheric Administration
NS = No standard
ORNL = Oak Ridge National Laboratory
UCL = Upper confidence limit
WSDH = Washington State Department of Health
µg/L = Microgram per liter

1a-State of Washington ambient water quality criteria for protection of human health (WDOE 2001d)
1b-State of Washington drinking water standards, WAC 246-290-310 (WSDH 2006)
2-EPA recommended chronic ambient water quality criteria for human consumption of water and fish (EPA 2004c)
3-State of Washington ambient water quality criteria for protection of aquatic life, chronic criterion (WDOE 2003a)
4-EPA recommended chronic ambient water quality criteria for freshwater aquatic life (EPA 2004c); if none existed then used Tier II secondary chronic values (NOAA
5-ORNL Ecological screening levels for freshwater, lowest chronic value (Suter & Tsao 1996)

TABLE 5
Sediment Analytical Results Summary
Sunset Mine and Millsite

Sample ID	TOC (%)	Analyte Concentration (mg/kg)																										
		Ca	K	Mg	Na	CN	Ag	Al	As_3	As_5	As_T	Ba	Be	Cd	Co	Cr_3	Cr_6	Cr_T	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
TC-SS-1 (background)	0.3	2640	1270	5660	310	0.2	0.68	11100	0.021	7.66	7.7	69.2	0.1	0.36	7	NA	NA	20	83.6	17500	0.025	475	17.4	9.96	0.1	0.3	0.07	33.5	85
minimum =	0.3	2640	1270	5660	310	0.2	0.68	11100	0.021	7.66	7.7	69.2	0.1	0.36	7	NA	NA	20	83.6	17500	0.025	475	17.4	9.96	0.1	0.25	0.07	33.5	85
MDC =	**0.3**	**2640**	**1270**	**5660**	**310**	**0.2**	**0.68**	**11100**	**0.021**	**7.66**	**7.7**	**69.2**	**0.1**	**0.36**	**7**	**NA**	**NA**	**20**	**83.6**	**17500**	**0.025**	**475**	**17.4**	**9.96**	**0.1**	**0.25**	**0.07**	**33.5**	**85**
average =	0.3	2640	1270	5660	310	0.2	0.68	11100	0.021	7.7	7.7	69.2	0.1	0.4	7	NA	NA	20	83.6	17500	0.025	475	17.4	10.0	0.1	0.25	0.07	33.5	85
NFSR[a]:																												
NFSR-SS-1	0.2	2910	1090	6230	300	NA	0.1	10800	0.017	35.4	35.4	43.7	0.1	0.36	8	NA	NA	18	44.8	19300	0.02	286	16.7	10.3	0.5	0.3	0.06	39.2	73
Site:																												
TC-SS-2	0.3	2600	1500	7780	260	0.2	0.17	11800	0.019	7.76	7.8	79.9	0.1	0.26	9	NA	NA	22	109	21300	0.025	548	27.8	6.4	0.3	0.3	0.07	40.7	92
TC-SS-3	0.4	2940	1680	6480	300	0.2	0.07	11800	0.018	7.17	7.2	67.2	0.1	0.31	8	NA	NA	21	102	21600	0.02	555	20.6	7.96	0.2	0.3	0.08	38.9	77
min (excluding BG) =	0.3	2600	1500	6480	260	0.2	0.07	11800	0.0175	7.17	7.2	67.2	0.1	0.26	8	NA	NA	21	102	21300	0.02	548	20.6	6.4	0.2	0.25	0.07	38.9	77
MDC (excluding BG) =	**0.4**	**2940**	**1680**	**7780**	**300**	**0.2**	**0.17**	**11800**	**0.019**	**7.76**	**7.8**	**79.9**	**0.1**	**0.31**	**9**	**NA**	**NA**	**22**	**109**	**21600**	**0.025**	**555**	**27.8**	**7.96**	**0.3**	**0.25**	**0.08**	**40.7**	**92**
avg (excluding BG) =	0.4	2770.0	1590.0	7130.0	280	0.2	0.12	11800	0.0	7.5	7.5	73.6	0.1	0.29	8.5	NA	NA	21.5	106	21450	0.023	552	24.2	7.2	0.3	0.25	0.08	39.8	85
95% UCL[b] =																NA	NA												
Freq detected =	100%	100%	100%	100%	100%	0%	100%	100%	25%	100%	100%	100%	0%	100%	100%	NA	NA	100%	100%	100%	0%	100%	100%	100%	100%	0%	100%	100%	100%
Human Health Screening Criteria																												
WDOE MTCA Method A Industrial Soil Cleanup Levels – Human Receptors (WDOE 2001b)		NS	NS	NS	NS	20	NS	NS	2	NS	2000	19	19	NS	NS	2	NS	NS	1000	NS	NS	NS	NS	NS				
EPA Region IX Industrial Soil PRGs (EPA 2004a)		5100	100000	NS	NS	1.6	67000	1900	450	1900	100000	30	450	41000	100000	310	19000	20000	800	410	5100	67	1000	100000				
Ecological Screening Criteria																												
State of Washington Development of Freshwater Sediment Quality Values (WDOE 2003b) - recommended only		2.0	NS	NS	NS	20.0	NS	NS	0.6	NS	NS	NS	95.0	80.0	NS	0.5	NS	60.0	335	0.4	NS	NS	NS	140				
State of Washington Development of Freshwater Sediment Quality Values (WDOE 2002) - in development		3.9	NS	NS	NS	5.9	NS	NS	0.6	NS	NS	NS	26.0	16.0	NS	0.17	NS	16.0	31.0	35.0	NS	NS	NS	110				
EPA Threshold Effects Level (NOAA 1999)		NS	NS	NS	NS	5.9	NS	NS	0.596	NS	NS	NS	37.3	35.7	NS	0.174	NS	18	35	NS	NS	NS	NS	123				
EPA Freshwater Probable Effects Level (NOAA 1999)		NS	NS	NS	NS	17	NS	NS	3.53	NS	NS	NS	90	197	NS	0.486	NS	35.9	91.3	NS	NS	NS	NS	315				
ORNL PRGs for Ecological Endpoints, Sediment (Efroymson et al. 1997)		1.8	NS	NS	NS	42	NS	NS	4.2	NS	NS	NS	159	77.7	NS	0.7	NS	38.5	110	NS	NS	NS	NS	270				

Notes:

Result below method detection limit, reported at 1/2 reporting limit

Result between method detection limit and practical quantitation limit, reported at detected concentration

Calculated value

Ecological screening criteria exceeded

Human health screening criteria exceeded

[a]Samples from NF Skykomish River were not included with samples from the site in determining minimum, maximum, and average concentrations.

[b]95 Percent upper confidence levels not computed because fewer than four samples.

EPA = U.S. Environmental Protection Agency

MDC = Maximum detected concentration

MTCA = Model Toxics Control Act

NA = Not analyzed for

NFSR = North Fork Skykomish River

NOAA = National Oceanic and Atmospheric Administration

NS = No standard

ORNL = Oak Ridge National Laboratory

PRG = Preliminary remediation goal

UCL = Upper confidence limit

WDOE = Washington Department of Ecology

mg/kg = Milligram per kilogram

TABLE 6
Pore Water Analytical Results Summary
Sunset Mine and Millsite

Sample ID	Analyte Concentration (ug/L)[a]																					
	Ag	Al	As_3	As_5	As_T	Ba	Be	Cd	Co	Cr_3	Cr_6	Cr_T	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
TC-PW1 (background)	0.025	15	0.045	0.26	0.3	4	1	0.05	5	5	0.01	5	0.7	5	0.00041	2.5	5	0.05	0.1	0.05	0.025	2.5	5
min background =	0.025	15	0.045	0.26	0.3	4	1	0.05	5	5	0.01	5	0.7	5	0.00041	2.5	5	0.05	0.1	0.05	0.025	2.5	5
max background =	**0.025**	**15**	**0.045**	**0.26**	**0.3**	**4**	**1**	**0.05**	**5**	**5**	**0.01**	**5**	**0.7**	**5**	**0.00041**	**2.5**	**5**	**0.05**	**0.1**	**0.05**	**0.025**	**2.5**	**5**
average background =	0.025	15	0.045	0.26	0.3	4	1	0.05	5	5	0.01	5	0.7	5	0.00041	2.5	5	0.05	0.1	0.05	0.025	2.5	5
NFSR[d]:																							
NFSR-PW1	0.025	15	0.0035	0.89	0.9	5	1	0.05	5	5	0.01	5	1.1	5	0.00068	2.5	5	0.05	0.1	0.05	0.025	2.5	5
Site:																							
TC-PW2	0.025	15	0.017	0.18	0.2	3	1	0.05	5	5	0.01	5	1.6	5	0.00061	2.5	5	0.05	0.1	0.05	0.025	2.5	5
TC-PW3	0.025	15	0.022	0.18	0.2	4	1	0.05	5	5	0.01	5	1.1	5	0.00052	2.5	5	0.05	0.1	0.05	0.025	2.5	5
min (excluding BG) =	0.025	15	0.017	0.18	0.2	3	1	0.05	5	5	0.01	5	1.1	5	0.00052	2.5	5	0.05	0.1	0.05	0.025	2.5	5
MDC (excluding BG) =	**0.025**	**15**	**0.022**	**0.18**	**0.2**	**4**	**1**	**0.05**	**5**	**5**	**0.01**	**5**	**1.6**	**5**	**0.00061**	**2.5**	**5**	**0.05**	**0.1**	**0.05**	**0.025**	**2.5**	**5**
avg (excluding BG) =	0.03	15	0.02	0.18	0.2	3.5	1	0.05	5	5	0.01	5	1.4	5	0.00056	2.5	5	0.05	0.1	0.05	0.025	2.5	5
95% UCL[c] =																							
Freq detected =	0%	0%	75%	100%	100%	100%	0%	0%	0%	0%	100%	0%	100%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
Ecological Screening Criteria																							
1- Wash Eco[b]	NS	NS	NS	NS	190	NS	NS	0.42	NS	63.7	10.4	NS	4.05	NS	0.012	NS	54.5	0.64	NS	5	NS	NS	36.6
2- EPA Eco[b]	0.36	NS	NS	3.1	150d	4	0.66	0.10	23	26.5	11d	NS	3.06	1000	0.77d	120	18.0	0.63	30	5	12	20	40.8
3 -ORNL Eco	0.36	87	0.19	0.0031	3.1	4	0.66	0.00015	23	NS	0.002	2	0.23	158	0.23	120	160	0.66	30	0.39	9	20	30

Sample ID	pH	Analyte Concentration (ug/L)[a]						
		Ca	Hard	K	Mg	Na	Sulfate	CN
TC-PW1 (background)	9.7	1700	5	150	300	700	10	0.005
min background =	9.7	1700	5	150	300	700	10	0.005
max background =	**9.7**	**1700**	**5**	**150**	**300**	**700**	**10**	**0.005**
average background =	9.7	1700	5	150	300	700	10	0.005
NFSR[d]:								
NFSR-PW1	7.0	2900	9	150	500	1700	5	NA
Site:								
TC-PW2	7.7	1700	5	150	200	700	5	0.005
TC-PW3	7.1	1700	5	150	200	700	5	0.005
min (excluding BG) =	7.1	1700	5	150	200	700	5	0.005
max (excluding BG) =	**7.7**	**1700**	**5**	**150**	**200**	**700**	**5**	**0.005**
avg (excluding BG) =	7.4	1700	5	150	200	700	5	0.005
95% UCL[c] =								
% Freq Detect =			100%	0%	100%	100%	0%	0%

1-State of Washington ambient water quality criteria for protection of aquatic life, chronic criterion (WDOE 2003a)

2-EPA recommended chronic ambient water quality criteria for freshwater aquatic life (EPA 2004c); if none existed, used Tier II secondary chronic values (NOAA 1999).

3-ORNL Ecological screening levels for freshwater, lowest chronic value (Suter & Tsao 1996)

Notes:

Result below method detection limit, reported at 1/2 reporting limit

Result between method detection limit and practical quantitation limit, reported at detected concentration

Calculated value

Ecological screening criteria exceeded

[a]Dissolved concentrations

[b]Screening criteria for hardness dependent metals are based on a average hardness of 5.

[c]95 Percent upper confidence levels not computed because fewer than four samples.

[d]Samples from NF Skykomish River not included with samples from site in determining minimum, maximum, and average concentrations.

BG = Background
EPA = U.S. Environmental Protection Agency
MDC = Maximum detected concentration
max = Maximum
min = Minimum
NA = Not analyzed for
NFSR = North Fork Skykomish River
NOAA = National Oceanic and Atmospheric Administration
NS = No standard
ORNL = Oak Ridge National Laboratory
UCL = Upper confidence limit
Wash = Washington
WDOE = Washington Department of Ecology
µg/L = Microgram per liter

TABLE 7
Preliminary Risk Screening Using BLM Risk Management Criteria
Sunset Mine and Millsite

Media and Receptor	Units	Contaminant of Interest										
		Sb	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
HUMAN HEALTH RISK SCREENING												
Background Soil MDC	mg/kg	**0.5**	**13**	**0.7**	**631**	**13.1**	**341**	**0.10**	**18.1**	**2.50**	**0.73**	**126**
Camper RMC	mg/kg	50	20	70	5000	1000	19000	40	2700	700	700	40000
Mine Waste MDC	mg/kg	**400**	**1150**	**5**	**883000**	**788**	**1400**	**5.74**	**30**	**50**	**268**	**1078**
Camper RMC	mg/kg	50	20	70	5000	1000	19000	40	2700	700	700	40000
Sediment MDC	mg/kg	**0.3**	**7.8**	**0.31**	**109**	**7.96**	**555**	**0.025**	**27.8**	**0.3**	**0.17**	**92**
Camper RMC	mg/kg	62	46	155	5745	1000	21679	46	3094	774	774	46455
Surface Water MDC	ug/L	**2.4**	**3**	**0.1**	**212**	**2.8**	**13**	**0.006**	**5.0**	**0.5**	**0.26**	**5**
Swimmer RMC	ug/L	192	144	239	17768	50	2395	144	9578	2395	2395	143677
Camper RMC	ug/L	124	93	155	11490	50	1548	93	6194	1548	1548	92909
ECOLOGICAL RISK SCREENING												
Background Soil MDC	mg/kg		**13**	**0.7**	**631**	**13.1**		**0.10**				**126**
Deer Mouse RMC	mg/kg		230	7	640	142		2				419
Mule Deer RMC	mg/kg		200	3	102	106		9				222
Elk RMC	mg/kg		328	3	131	127		11				275
Mallard RMC	mg/kg		116	1	141	59		4				196
Canada Goose RMC	mg/kg		61	2	161	34		6				271
Robin RMC	mg/kg		4	0.3	7	6		1				43
Mine Waste MDC	mg/kg		**1150**	**5**	**883000**	**788**		**5.74**				**1078**
Deer Mouse RMC	mg/kg		230	7	640	142		2				419
Mule Deer RMC	mg/kg		200	3	102	106		9				222
Elk RMC	mg/kg		328	3	131	127		11				275
Mallard RMC	mg/kg		116	1	141	59		4				196
Canada Goose RMC	mg/kg		61	2	161	34		6				271
Robin RMC	mg/kg		4	0.3	7	6		1				43

Notes:

< RMC = low risk

1 to 10X RMC = moderate risk

10 to 100X RMC = high risk

> 100X RMC = extremely high risk

BLM = U.S. Bureau of Land Management

MDC = Maximum detected concentration

RMC = Risk management criteria

mg/kg = Milligram per kilogram

µg/L = Microgram per liter

TABLE 8
Human Health COPC Summary
Sunset Mine and Millsite

COPC	Media			
	Mine Waste	Sediment	Surface Water	Multi-Media
Aluminum	<SC	<SC	<SC	
Antimony	<SC	<SC	<SC	**X**
Arsenic	**X**	**X**	**X**	**X**
Barium	<SC	<SC	<SC	
Beryllium	<SC	<5%	<5%	
Cadmium	**X**	<BG	<SC	**X**
Chromium	**X**	**X**	<5%	**X**
Cobalt	<SC	<SC	<5%	
Copper	**X**	<SC	<SC	**X**
Iron	**X**	<SC	<SC	**X**
Lead	<SC	<BG	<SC	**X**
Manganese	<SC	<SC	<SC	
Mercury	**X**	<5%	<SC	**X**
Nickel	<SC	<SC	<5%	
Selenium	<SC	<5%	<5%	
Silver	<SC	<BG	<SC	
Thallium	<SC	<SC	<BG	
Vanadium	<SC	<SC	<5%	
Zinc	<SC	<SC	<5%	
Cyanide	NA	<5%	NA	

Notes:
COPC = Contaminant of potential concern
MDC = Maximum detected concentration
NA = Not analyzed for
X = Retained as a COPC
<BG = Screened out because MDC below background level
<SC = Screened out because MDC below screening criteria
<5% = Screened out because not detected in more than 5% of the samples

TABLE 9
Human Health Exposure Point Concentration Summary
Sunset Mine and Millsite

COPC	Exposure Point Concentration					
	RME[a]			CTE[b]		
	Mine Waste (mg/kg)	Surface Water (mg/L)	Sediment[c] (mg/kg)	Mine Waste (mg/kg)	Surface Water (mg/L)	Sediment (mg/kg)
Antimony	261	0.0001	0.30	30.5	0.001	0.25
Arsenic	782	0.0002	7.8	126	0.002	7.5
Cadmium	2.6	0.00005	0.31	1.5	0.0001	0.29
Chromium	21.0	0.005	22.0	16.2	0.005	21.5
Copper	584395	0.0008	109	63197	0.09	106
Iron	80999	0.005	21600	60765	0.08	21450
Mercury	1.7	0.0000004	0.03	1.0	0.000003	0.02

Notes:

[a]95 percent upper confidence limit (UCL_{95}); if UCL_{95} > maximum detected concentration (MDC), used MDC

[b]Arithmetic mean concentration

[c]MDC; UCL_{95} not computed because fewer than 4 samples

Exposure point concentrations not calculated for lead because lead risks were not quantified

COPC = Contaminant of potential concern

CTE = Central tendency

RME = Reasonable maximum exposure

mg/kg = Milligram per kilogram

mg/L = Milligram per liter

TABLE 10
Human Health Exposure Factor Summary
Sunset Mine and Millsite

Medium	Exposure Route	Parameter Code	Parameter Definition	Units	Adult Recreationalist			Child Recreationalist		
					RME Value	CTE Value	Reference	RME Value	CTE Value	Reference
All	All	BW	Body Weight	kg	70	70	EPA 1997a	15	15	EPA 1997a
		AT-C	Averaging Time (Cancer)	day	25,550	25,550	EPA 1989	25,550	25,550	EPA 1997a
		AT-N	Averaging Time (Non-Cancer)	day	10,950	3,285	365 x ED	2,190	2,190	365 x ED
		CF1	Conversion Factor	1 kg/mg	1.0E-06	1.0E-06		1.0E-06	1.0E-06	
		CF2	Conversion Factor	L/cm^3	1.0E-03	1.0E-03		1.0E-03	1.0E-03	
Mine Waste	Ingestion	IR-S	Incidental Ingestion Rate of Soil	mg/day	100	50	EPA 1997a	400	100	EPA 1997a
		EF	Exposure Frequency	day/year	14	7	(1)	14	7	(1)
		ED	Exposure Duration	years	30	9	(1)	6	6	(1)
	Dermal	SA	Skin Surface Area Available for Contact	cm^2	6,900	5,200	EPA 2004	5,000	4,500	EPA 2004
		DAF	Dermal Absorption Factor	--	CS	CS	EPA 2004	CS	CS	EPA 2004
		SSAF	Soil to Skin Adherence Factor	mg/cm^2-day	0	0	EPA 2004	1	0	EPA 2004
	Inhalation	IN	Inhalation Rate	m^3/day	15	15	EPA 1997a	8	8	EPA 1997a
		PEF	Particulate Emission Factor	m^3/kg	1.31.E+09	1.31.E+09	EPA 2000	1.31.E+09	1.31.E+09	EPA 2004
Sediment	Ingestion	IR-S	Incidental Ingestion Rate of Sediment	mg/day	50	25	EPA 1997a	200	50	EPA 1997a
		EF	Exposure Frequency	day/year	14	7	(1)	14	7	(1)
		ED	Exposure Duration	years	30	9	(1)	6	6	(1)
	Dermal	SA	Skin Surface Area Available for Contact	cm^2	5,700	5,700	EPA 2004	2,800	2,800	EPA 2004
		DAF	Dermal Absorption Factor[a]	unitless	CS	CS	EPA 2004	CS	CS	EPA 2004
		SSAF	Soil to Skin Adherence Factor	mg/cm^2/day	0	0	EPA 2004	0	0	EPA 2004
Surface Water	Ingestion	IR-W	Ingestion Rate of Surface Water	L/day	2	1	EPA 1997a	1	1	EPA 1997a
		EF	Exposure Frequency	day/year	14	7	(1)	14	7	(1)
		ED	Exposure Duration	years	30	9	(1)	6	6	(1)
	Dermal	SA	Skin Surface Area Available for Contact	cm^2	18,000	18,000	EPA 2004	6,000	6,000	EPA 2004
		KP	Permeability Coefficient	cm/hr	CS	CS	EPA 2004	CS	CS	EPA 2004
		EVF	Event Frequency	event/day	1	1	0	1	1	Site specific
		ET	Exposure Time	hr/day	2	2	EPA 1997a	2	2	EPA 1997a

Notes:

(1) Site-specific assumed value

EPA 1997a "Exposure Factors Handbook." Volumes I through III. Office of Research and Development. EPA/600/P-95/002Fa, -Fb, -Fc. August.

EPA 2004a "Region 9 Preliminary Remediation Goals (PRGs) Table." November 2004. On-line address: http://www.epa.gov/region9/waste/sfund/prg/whatsnew.htm.

EPA 2004 "Risk Assessment Guidance for Superfund, Part E, Supplemental Guidance for Dermal Risk Assessment." Volume I: Human Heath Evaluation Manual. Final. Office of Superfund Remediation and Technology Innovation. July.

CTE = Central tendency exposure

RME = Reasonable maximum exposure

cm/hr = Centimeter per hour

cm^2 = Square centimeter

hr/day = Hour per day

kg/gm = Kilogram per milligram

L/day = Liter per day

L/cm^3 = Liter per cubic centimeter

mg/cm^2-day = Milligram per square centimeter per day

mg/day = Milligram per day

m^3/day = Cubic meter per day

m^3/kg = Cubic meter per kilogram

TABLE 11
Human Health Hazard and Cancer Risk Summary
Sunset Mine and Millsite

Media	Exposure Pathway	CENTRAL TENDENCY EXPOSURE				REASONABLE MAXIMUM EXPOSURE			
		Adult Recreationalist		Child Recreationalist		Adult Recreationalist		Child Recreationalist	
		Non-carcinogenic HI	Carcinogenic ECR	Non-carcinogenic HI	Carcinogenic ECR	Non-carcinogenic HI	Carcinogenic ECR	Non-carcinogenic HI	Carcinogenic ECR
Mine Waste	Ingestion	0.03	3.E-07	0.3	**2.E-06**	1	**3.E-05**	**20**	**1.E-04**
	Dermal	0.005	2.E-07	0.07	**2.E-06**	0.08	**1.E-05**	**3**	**9.E-05**
	Inhalation	0.000002	3.E-09	0.000005	5.E-09	0.000005	5.E-08	0.00001	2.E-08
	Subtotal =	0.04	5.E-07	0.4	**4.E-06**	1	**4.E-05**	**23**	**2.E-04**
Surface Water	Ingestion	0.004	2.E-07	0.01	3.E-07	0.02	**2.E-06**	0.07	1.E-06
	Dermal	0.001	1.E-08	0.003	1.E-08	0.001	9.E-08	0.01	3.E-08
	Subtotal =	0.005	2.E-07	0.02	3.E-07	0.02	**3.E-06**	0.08	1.E-06
Sediment	Ingestion	0.001	1.E-08	0.006	6.E-08	0.003	1.E-07	0.05	5.E-07
	Dermal	0.00003	2.E-09	0.0003	1.E-08	0.0004	8.E-08	0.003	1.E-07
	Subtotal =	0.001	1.E-08	0.007	7.E-08	0.003	2.E-07	0.06	6.E-07
TOTAL =		0.04	7.E-07	0.4	**4.E-06**	1	**4.E-05**	**23**	**2.E-04**

Notes:

ECR = Excess cancer risk

HI = Hazard index

Bold values exceed risk screening levels

TABLE 12
Human Health Risk-based Hot Spot Concentrations
Sunset Mine and Millsite

Media	COPC	Calculated Hot Spot Concentration		Samples and Areas Exceeding Hot Spot Concentrations			
				Sample	Concentration		Area
Mine Waste/Soil	Antimony	2520	mg/kg	None			
	Arsenic	410	mg/kg	SM-WR7	1150	mg/kg	Waste rock pile WR-2, southeast pile
	Cadmium	4560	mg/kg	None			
	Chromium	8410980	mg/kg	None			
	Copper	365730	mg/kg	SM-WR5-1	883000	mg/kg	Waste rock pile WR-5
	Iron	3079680	mg/kg	None			
	Mercury	2610	mg/kg	None			
Sediment	Antimony	7203	mg/kg	None			
	Arsenic	1320	mg/kg	None			
	Cadmium	16040	mg/kg	None			
	Chromium	30796800	mg/kg	None			
	Copper	753150	mg/kg	None			
	Iron	6159370	mg/kg	None			
	Mercury	132396	mg/kg	None			

Notes:
COPC = Contaminant of potential concern
mg/kg = Milligram per kilogram

TABLE 13
Human Health Risk-based Cleanup Levels
Sunset Mine and Millsite

Media	COPC	Calculated Cleanup Level		Samples and Areas Exceeding Cleanup Levels			
				Sample	Concentration		Area
Mine Waste/Soil	Antimony	252	mg/kg	SM-WR5-1	400[a]	mg/kg	Waste rock pile WR-5
	Arsenic	41	mg/kg	SM-S1	60	mg/kg	Soil south of mill foundation
				SM-S3	50	mg/kg	
				SM-WR1-1	50	mg/kg	Waste rock pile WR-1
				SM-WR8	49	mg/kg	
				SM-WR9	60	mg/kg	
				SM-WR2-1	280	mg/kg	Waste rock pile WR-2, northwest pile
				SM-WR2-2	110	mg/kg	
				SM-WR7	1150	mg/kg	Waste rock pile WR-2, southeast pile
				SM-WR5-1	133	mg/kg	Waste rock pile WR-5
				SM-WR6-2	63	mg/kg	Waste rock pile WR-6
	Cadmium	456	mg/kg	None			
	Chromium	841098	mg/kg	None			
	Copper	36573	mg/kg	SM-WR5-1	883000	mg/kg	Waste rock pile WR-5
	Iron	307968	mg/kg	None			
	Mercury	261	mg/kg	None			
Sediment	Antimony	7203	mg/kg	None			
	Arsenic	132	mg/kg	None			
	Cadmium	1604	mg/kg	None			
	Chromium	3079680	mg/kg	None			
	Copper	75315	mg/kg	None			
	Iron	615937	mg/kg	None			
	Mercury	13239	mg/kg	None			

Notes:

[a]Analytical result reported as below the method detection limit (MDL); value = 1/2 reporting limit

COPC = Contaminant of potential concern

mg/kg = Milligram per kilogram

TABLE 14
Mine Waste Contaminants of Potential Ecological Concern
Sunset Mine and Millsite

CPEC	Risk from Single COI				Risk from Multiple COIs			
	Plant	Invertebrate	Bird	Mammal	Plant	Invertebrate	Bird	Mammal
Silver	**X**	**X**	No SLV[a]	No SLV[a]				
Aluminum	**X**	**X**	**X**	**X**				**X**
Arsenic III	Q<1	Q<5	Q<1	Q<1				
Arsenic V	**X**	Q<5	**X**	**X**				
Arsenic Total	No SLV[a]	No SLV[a]	No SLV[a]	No SLV[1]				
Barium	Q<1	Q<5	**X**	**X**				
Beryllium	Q<1	No SLV[a]	No SLV[a]	Q<1				
Cadmium	**X**	Q<5	Q<1	Q<1				
Cobalt	**X**	Q<5	No SLV[a]	Q<1				
Chromium III	NA	NA	NA	NA				
Chromium VI	No SLV[a]	No SLV[a]	No SLV[a]	Q<1				
Chromium Total	**X**	Q<5	Q<1	No SLV[1]				
Copper	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Iron	**X**	**X**	No SLV[a]	No SLV[1]	**X**			
Mercury	**X**	**X**	**X**	Q<1				
Manganese	**X**	**X**	Q<1	Q<1				
Nickel	**X**	Q<5	Q<1	Q<1				
Lead	**X**	Q<5	**X**	Q<1				
Antimony	**X**	No SLV[a]	No SLV[a]	**X**				
Selenium	**X**	Q<5	**X**	**X**				
Thallium	**X**	No SLV[a]	No SLV[a]	**X**				
Vanadium	**X**	No SLV[a]	Q<1	**X**				
Zinc	**X**	**X**	**X**	Q<1				
Cyanide	NA	NA	NA	NA				

Notes:
[a]Retained because of the lack of an SLV; may or may not present an ecological risk
COI = Contaminant of interest
CPEC = Contaminant of potential ecological concern
NA = Not analyzed for
SLV = Screening level value
X = Retained as CPEC
Q<1, Q<5 = Screened out because risk ratio below screening level

TABLE 15
Surface Water Contaminants of Potential Ecological Concern
Sunset Mine and Millsite

CPEC	Risk from Single COI			Risk from Multiple COIs		
	Aquatic Life	Bird	Mammal	Aquatic Life	Bird	Mammal
Silver	**X**	No SLV[a]	No SLV[a]			
Aluminum	**X**	Q<1	Q<1		**X**	**X**
Arsenic III	Q<1	Q<1	Q<1			
Arsenic V	Q<1	No SLV[a]	No SLV[a]			
Arsenic Total	Q<1	No SLV[a]	No SLV[a]			
Barium	**X**	Q<1	Q<1			
Beryllium	<5%	<5%	<5%			
Cadmium	<BG	<BG	<BG			
Cobalt	<5%	<5%	<5%			
Chromium III	<5%	<5%	<5%			
Chromium VI	<5%	<5%	<5%			
Chromium Total	<5%	<5%	<5%			
Copper	**X**	Q<1	Q<1	**X**	**X**	
Iron	Essential	Essential	Essential			
Mercury	Q<1	Q<1	Q<1			
Manganese	Q<1	Q<1	Q<1			
Nickel	<5%	<5%	<5%			
Lead	**X**	Q<1	Q<1			
Antimony	No SLV[a]	No SLV[a]	Q<1			
Selenium	<5%	<5%	<5%			
Thallium	<BG	<BG	<BG			
Vanadium	<5%	<5%	<5%			
Zinc	<5%	<5%	<5%			
Cyanide	NA	NA	NA			

Notes:

[a]Retained because of the lack of an SLV; may or may not present an ecological risk.

COI = Contaminant of interest

CPEC = Contaminant of potential ecological concern

Essential = Screened out because essential nutrient

NA = Not analyzed for

SLV = Screening level value

X = Retained as CPEC

<BG = Screened out because MDC below background level

<5% = Screened out because not detected in 5% or more of the samples

Q<1 = Screened out because risk ratio below screening level

TABLE 16
Sediment Contaminants of Potential Ecological Concern
Sunset Mine and Millsite

CPEC	Freshwater Sediment Risk	Bioaccumulation Risk
Silver	<BG	<BG
Aluminum	No SLV[a]	No SLV[a]
Arsenic III	<BG	<BG
Arsenic V	No SLV[a]	No SLV[a]
Arsenic Total	Q<1	No SLV[a]
Barium	No SLV[a]	No SLV[a]
Beryllium	<5%	<5%
Cadmium	<BG	<BG
Cobalt	No SLV[a]	No SLV[a]
Chromium III	NA	NA
Chromium VI	NA	NA
Chromium Total	Q<1	Q<1
Copper	**X**	**X**
Iron	Essential	Essential
Mercury	<5%	<5%
Manganese	No SLV[a]	Q<1
Nickel	Q<1	Q<1
Lead	<BG	<BG
Antimony	Q<1	Q<1
Selenium	<5%	<5%
Thallium	No SLV[a]	Q<1
Vanadium	No SLV[a]	No SLV[a]
Zinc	Q<1	**X**
Cyanide	<5%	<5%

Notes:

[a]Retained because of the lack of an SLV; may or may not present an ecological risk.

COI = Contaminant of interest

CPEC = Contaminant of potential ecological concern

Essential = Screened out because essential nutrient

NA = Not analyzed for

SLV = Screening level value

X = Retained as CPEC

<BG = Screened out because MDC below background level

<5% = Screened out because not detected in 5% or more of the samples

Q<1 = Screened out because risk ratio below screening level

TABLE 17
Pore Water Contaminants of Potential Ecological Concern
Sunset Mine and Millsite

CPEC	Aquatic Life	
	Risk from Single COI	Risk from Multiple COIs
Silver	<5%	
Aluminum	<5%	
Arsenic III	<BG	
Arsenic V	<BG	
Arsenic Total	<BG	
Barium	<BG	
Beryllium	<5%	
Cadmium	<5%	
Cobalt	<5%	
Chromium III	<5%	
Chromium VI	<5%	
ChromiumTotal	<5%	
Copper	Q<1	
Iron	<5%	
Mercury	Q<1	
Manganese	<5%	
Nickel	<5%	
Lead	<5%	
Antimony	<5%	
Selenium	<5%	
Thallium	<5%	
Vanadium	<5%	
Zinc	<5%	
Cyanide	<5%	

Notes:
COI = Contaminant of interest
CPEC = Contaminant of potential ecological concern
Q<1 = Screened out because risk ratio below screening level
X = Retained as CPEC
<BG = Screened out because MDC below background level
<5% = Screened out because not detected in 5% or more of the samples

TABLE 18
Multiple Media Contaminants of Potential Ecological Concern
Sunset Mine and Millsite

CPEC	Bird	Mammal
Aluminum	**X**	**X**
Arsenic V	**X**	**X**
Barium	**X**	**X**
Copper	**X**	**X**
Mercury	**X**	
Manganese	**X**	
Lead	**X**	
Antimony		**X**
Selenium	**X**	**X**
Thallium		**X**
Vanadium		**X**
Zinc	**X**	

Notes:
CPEC = Contaminant of potential ecological concern

TABLE 19
Contaminants of Potential Ecological Concern Summary
Sunset Mine and Millsite

CPEC	Media				Mutiple Media
	Mine Waste	Surface Water	Sediment	Pore Water	
Silver	**P,I,** B[a], M[a]	**Aq,** B[a], M[a]	<BG	<5%	
Aluminum	**P, I, B, M**	**Aq**	Fw[a], Bio[a]	<5%	**B, M**
Arsenic III	Q<1, 5	Q<1	<BG	<BG	
Arsenic V	**P, B, M**	B[a], M[a]	Fw[a], Bio[a]	<BG	**B, M**
Arsenic Total	P[a],I[a], B[a], M[a]	B[a], M[a]	Fw[a]	<BG	
Barium	**B, M**	**Aq**	Fw[a], Bio[a]	<BG	**B, M**
Beryllium	I[a], B[a]	<5%		<5%	
Cadmium	**P**	<BG	<BG	<5%	
Cobalt	**P,** B[a]	<5%	Fw[a], Bio[a]	<5%	
Chromium III	NA	<5%	NA	<5%	
Chromium VI	P[a],I[a], B[a]	<5%	NA	<BG	
Chromium Total	**P,** M[a]	<5%	Q<1	<5%	
Copper	**P, I, B, M**	**Aq**	**Fw, Bio**	Q<1	**B, M**
Iron	**P, I,** B[a]	Essential	Essential	<5%	
Mercury	**P, I, B**	Q<1	<5%	Q<1	**B**
Manganese	**P, I**	Q<1	Fw[a]	<5%	
Nickel	**P**	<5%	Q<1	<5%	
Lead	**P, B**	**Aq**	Q<1	<5%	**B**
Antimony	**P, M,** I[a], B[a]	Aq[a], B[a]	Q<1	<5%	**M**
Selenium	**P, B, M**	<5%	<5%	<5%	**B, M**
Thallium	**P, M,** I[a], B[a]	<BG	Bio[a]	<5%	**M**
Vanadium	**P, M,** I[a]	<5%	Fw[a], Bio[a]	<5%	**M**
Zinc	**P, I, B**	<5%	**Bio**	<5%	**B**
Cyanide	NA	NA	<5%	<5%	

Notes:
[a]Retained because of the lack of an SLV; may or may not present an ecological risk
Aq = Aquatic life
B = Bird
Bio = Bioaccumulation risk
CPEC = Contaminant of potential ecological concern
Essential = Screened out because essential nutrient
Fw = Freshwater risk
I = Invertebrate
M = Mammal
NA = Not analyzed for
P = Plant
SLV = Screening level value
<BG = Screened out because MDC below background level
<5% = Screened out because not detected in 5% or more of the samples
Q<1, Q<5 = Screened out because risk ratio below screening level

TABLE 20
Ecological Risk Ratio Summary
Sunset Mine and Millsite

CPEC	Mine Waste				Surface Water			Sediment		Pore Water	Multiple Media	
	Plant	Invertebrate	Bird	Mammal	Bird	Mammal	Aquatic Life	Freshwater	Bio-accumulation	Aquatic Life	Bird	Mammal
Silver	**134**	**5.4**	NS	NS	NS	NS	**2**	-	-	-	-	-
Aluminum	**448**	**37**	**50**	**209**	<1	<1	**3**	NS	NS	**-**	**X**	**X**
Arsenic III	<1	<5	<1	<1	<1	<1	<1	-	-	**-**	**-**	**-**
Arsenic V	**13**	<5	**1.01**	**1.01**	NS	NS	<1	NS	NS	**-**	**X**	**X**
Arsenic Total	NS	NS	NS	NS	NS	NS	<1	<1	NS	**-**	**-**	**-**
Barium	<1	<5	**1.3**	**1.1**	<1	<1	**5**	NS	NS	**-**	**X**	**X**
Beryllium	<1	NS	NS	<1	-	-	-	-	-	**-**	**-**	**-**
Cadmium	**1.3**	<5	<1	<1	<1	<1	<1	-	-	**-**	**-**	**-**
Cobalt	**1.3**	<5	NS	<1	-	-	-	NS	NS	**-**	**-**	**-**
Chromium III	NA	NA	NA	NA	-	-	-	-	-	**-**	**-**	**-**
Chromum VI	NS	NS	NS	<1	-	-	-	-	-	**-**	**-**	**-**
Chromium Total	**1.4**	<5	<1	NS	-	-	-	<1	<1	**-**	**-**	**-**
Copper	**8830**	**17660**	**4069**	**2264**	<1	<1	**42**	**1.4**	**11**	<1	**X**	**X**
Iron	**22600**	**1130**	NS	NS	-	-	-	-	-	-	-	-
Mercury	**19**	**57**	**1.04**	<1	<1	<1	<1	-	-	<1	**X**	-
Manganese	**1.3**	**14**	<1	<1	<1	<1	<1	NS	<1	-	-	-
Nickel	<1	<5	<1	<1	-	-	-	<1	<1	-	-	-
Lead	**16**	<5	**7**	<1	<1	<1	**4**	<1	<1	-	**X**	-
Antimony	**80**	NS	NS	**27**	-	<1	**-**	<1	<1	-	-	**X**
Selenium	**50**	<5	**167**	**2**	-	-	-	-	-	-	-	**X**
Thallium	**3**	NS	NS	**3**	-	-	-	NS	<1	-	-	**X**
Vanadium	**22**	NS	<1	**2**	-	-	-	NS	NS	-	-	**X**
Zinc	**13**	**5.4**	**3**	<1	-	-	-	<1	**31**	-	**X**	-

Notes:
CPEC = Contaminant of potential ecological concern
NA = Not analyzed for
NS = No screening level value
- = Not calculated because not a CPEC for this medium
<1, <5 = Screened out because risk ratio below screening level

APPENDIX A

HUMAN HEALTH RISK CALCULATION TABLES

TABLE A.1
Human Health Exposure Pathways and Receptors
Sunset Mine and Millsite

Scenario Timeframe	Media	Exposure Media	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-site/ Off-site	Type of Analysis	Rationale for Selection or Exlusion of Exposure Pathway
Current	Soil	Soil	Mine Waste	Recreationalist	Adult Child	Ingestion Dermal Inhalation	On-Site	Quantitative	Current (Baseline)
	Sediment	Sediment	Adit Discharge and Trout Creek	Recreationalist	Adult Child	Ingestion Dermal	On-Site	Quantitative	Current (Baseline)
	Surface Water	Surface Water	Adit Discharge and Trout Creek	Recreationalist	Adult Child	Ingestion Dermal	On-Site	Quantitative	Current (Baseline)

TABLE A.2
Human Health Contaminant of Potential Concern Screening
Sunset Mine and Millsite

		Mine Waste Screening											Surface Water Screening											Sediment Screening											Multimedia	
Metal	Essential Nutrient?	Detect Freq	Detect Freq > 5% Retain as COPC?	MDC (C_{ij})	Avg BG Conc	MDC>BG Retain as COPC?	Soil Screening Criteria[b] (PRG_{ij})	Units	R_{ij} (C_{ij}/PRG_j)	MDC>PRG Retain as COPC?	R_{ij}/R_j	Multi COI Retain as COPC?	Detect Freq	Detect Freq > 5% Retain as COPC?	MDC (C_{ij})	Avg BG Conc	MDC>BG Retain as COPC?	Drinking Water Screening Criteria[c] (PRG_{ij})	Units	R_{ij} (C_{ij}/PRG_j)	MDC>PRG Retain as COPC?	R_{ij}/R_j	Multi COI Retain as COPC?	Detect Freq	Detect Freq > 5% Retain as COPC?	MDC (C_{ij})	MDC BG Conc	MDC>BG Retain as COPC?	Soil Screening Criteria[b] (PRG_{ij})	Units	R_{ij} (C_{ij}/PRG_j)	MDC>PRG Retain as COPC?	R_{ij}/R_j	Multi COI Retain as COPC?	Sum R_{ij}	Multi media Retain as COPC?
Aluminum	No	100%	**Yes**	22400	14633	**Yes**	1.0E+05	mg/kg	2.24E-01	No	2.95E-04	No	100%	**Yes**	270	50	**Yes**	36000	ug/L	7.50E-03	No	9.86E-05	No	100%	**Yes**	11800	11100	**Yes**	1.0E+05	mg/kg	1.18E-01	No	1.78E-02	No	3.50E-01	No
Antimony	No	18%	**Yes**	400	0.2	**Yes**	4.1E+02	mg/kg	9.76E-01	No	1.29E-03	No	38%	**Yes**	2.4	0.2	**Yes**	6	ug/L	4.00E-01	No	5.26E-03	No	100%	**Yes**	0.3	0.1	**Yes**	4.1E+02	mg/kg	7.32E-04	No	1.10E-04	No	1.38E+00	**Yes**
Arsenic$_3$	No	100%	**Yes**	0.5	0.04	**Yes**							88%	**Yes**	0.13	0.06	**Yes**							25%	**Yes**	0.019	0.021	No								
Arsenic$_5$	No	100%	**Yes**	132.7	10.9	**Yes**							63%	**Yes**	3.2	0.20	**Yes**							100%	**Yes**	7.76	7.7	**Yes**								
Arsenic$_{Tot}$	No	94%	**Yes**	1150	11.0	**Yes**	1.6E+00	mg/kg	7.19E+02	**Yes**	9.47E-01	**Yes**	88%	**Yes**	3.3	0.2	**Yes**	0.045	ug/L	7.33E+01	**Yes**	9.64E-01	**Yes**	100%	**Yes**	7.8	7.7	**Yes**	1.6E+00	mg/kg	4.88E+00	**Yes**	7.36E-01	**Yes**	7.97E+02	**Yes**
Barium	No	100%	**Yes**	111	83	**Yes**	6.7E+04	mg/kg	1.66E-03	No	2.18E-06	No	88%	**Yes**	20	3	**Yes**	2000	ug/L	1.00E-02	No	1.31E-04	No	100%	**Yes**	79.9	69.2	**Yes**	6.7E+04	mg/kg	1.19E-03	No	1.80E-04	No	1.28E-02	No
Beryllium	No	35%	**Yes**	1.0	0.1	**Yes**	1.9E+03	mg/kg	5.26E-04	No	6.94E-07	No	0%	No	1	1	No	4	ug/L	2.50E-01	No	3.29E-03	No	0%	No	0.1	0.1	No	1.9E+03	mg/kg	5.26E-05	No	7.94E-06	No	2.51E-01	No
Cadmium	No	47%	**Yes**	5	0.54	**Yes**	2.0E+00	mg/kg	2.50E+00	**Yes**	3.29E-03	No	38%	**Yes**	0.1	0.10	No	5	ug/L	2.00E-02	No	2.63E-04	No	100%	**Yes**	0.31	0.36	No	2.0E+00	mg/kg	1.55E-01	No	2.34E-02	No	2.68E+00	**Yes**
Calcium	**Yes**	100%	**Yes**	13400	2287	**Yes**				No[b]		No	100%	**Yes**	20400	1800	**Yes**				No[a]			100%	**Yes**	2940	2640	**Yes**				No[a]				No[a]
Chromium$_3$	No	NA	No										0%	No	5	5	No	55000	ug/L	9.09E-05	No	1.19E-06	No	NA	No										9.09E-05	No
Chromium$_6$	No	40%	**Yes**	103.60	0.52	**Yes**	1.9E+01	mg/kg	5.45E+00	**Yes**	7.18E-03	No	0%	No	0.5	0.5	No	110	ug/L	4.55E-03	No	5.97E-05	No	NA	No										5.46E+00	**Yes**
Chromium$_{tot}$	No	100%	**Yes**	59	14.7	**Yes**	1.9E+01	mg/kg	3.11E+00	**Yes**	4.09E-03	No	0%	No	5	5	No	100	ug/L	5.00E-02	No	6.57E-04	No	100%	**Yes**	22	20	**Yes**	1.9E+01	mg/kg	1.16E+00	**Yes**	1.75E-01	**Yes**	4.31E+00	**Yes**
Cobalt	No	94%	**Yes**	26	7.0	**Yes**	1.9E+03	mg/kg	1.37E-02	No	1.80E-05	No	0%	No	5	5	No	730	ug/L	6.85E-03	No	9.00E-05	No	100%	**Yes**	9	7	**Yes**	1.9E+03	mg/kg	4.74E-03	No	7.15E-04	No	2.53E-02	No
Copper	No	100%	**Yes**	883000	348	**Yes**	4.1E+04	mg/kg	2.15E+01	**Yes**	2.84E-02	No	75%	**Yes**	212	0.50	**Yes**	1300	ug/L	1.63E-01	No	2.14E-03	No	100%	**Yes**	109	84	**Yes**	4.1E+04	mg/kg	2.66E-03	No	4.01E-04	No	2.17E+01	**Yes**
Iron	**Yes**	100%	**Yes**	226000	16000	**Yes**	1.0E+05	mg/kg	2.26E+00	**Yes**	2.98E-03	No	75%	**Yes**	380	20	**Yes**	300	ug/L	1.27E+00	No[d]	1.66E-02	No	100%	**Yes**	21600	17500	**Yes**	1.0E+05	mg/kg	2.16E-01	No	3.26E-02	No	3.74E+00	**Yes**
Lead	No	100%	**Yes**	788	9	**Yes**	8.0E+02	mg/kg	9.85E-01	No	1.30E-03	No	38%	**Yes**	2.8	0.40	**Yes**	15	ug/L	1.87E-01	No	2.45E-03	No	100%	**Yes**	7.96	9.96	No	8.0E+02	mg/kg	9.95E-03	No	1.50E-03	No	1.18E+00	**Yes**
Magnesium	**Yes**	100%	**Yes**	9250	4207	**Yes**				No[b]		No	100%	**Yes**	2600	300	**Yes**				No[a]			100%	**Yes**	7780	5660	**Yes**				No[a]				No[a]
Manganese	No	100%	**Yes**	1400	243	**Yes**	1.9E+04	mg/kg	7.37E-02	No	9.71E-05	No	13%	**Yes**	13	2.5	**Yes**	50	ug/L	2.60E-01	No[d]	3.42E-03	No	100%	**Yes**	555	475	**Yes**	1.9E+04	mg/kg	2.92E-02	No	4.41E-03	No	3.63E-01	No
Mercury	No	94%	**Yes**	5.74	0.06	**Yes**	2.0E+00	mg/kg	2.87E+00	**Yes**	3.78E-03	No	100%	**Yes**	0.00604	0.00046	**Yes**	2	ug/L	3.02E-03	No	3.97E-05	No	0%	No	0.03	0.03	No	2.0E+00	mg/kg	1.25E-02	No	1.89E-03	No	2.89E+00	**Yes**
Nickel	No	53%	**Yes**	30	13.0	**Yes**	2.0E+04	mg/kg	1.50E-03	No	1.98E-06	No	0%	No	5	5	No	100	ug/L	5.00E-02	No	6.57E-04	No	100%	**Yes**	27.8	17.4	**Yes**	2.0E+04	mg/kg	1.39E-03	No	2.10E-04	No	5.29E-02	No
Potassium	**Yes**	100%	**Yes**	2530	492	**Yes**				No[b]		No	63%	**Yes**	800	150	**Yes**				No[a]			100%	**Yes**	1680	1270	**Yes**				No[a]				No[a]
Selenium	No	29%	**Yes**	50.0	1.1	**Yes**	5.1E+03	mg/kg	9.80E-03	No	1.29E-05	No	0%	No	1	0	No	180	ug/L	2.78E-03	No	3.65E-05	No	0%	No	0.25	0.25	No	5.1E+03	mg/kg	4.90E-05	No	7.40E-06	No	1.26E-02	No
Silver	No	94%	**Yes**	268	0.6	**Yes**	5.1E+03	mg/kg	5.25E-02	No	6.92E-05	No	25%	**Yes**	0.26	0.050	**Yes**	100	ug/L	2.60E-03	No	3.42E-05	No	100%	**Yes**	0.17	0.68	No	5.1E+03	mg/kg	3.33E-05	No	5.03E-06	No	5.52E-02	No
Sodium	**Yes**	100%	**Yes**	210	153	**Yes**				No[b]		No	100%	**Yes**	2800	700	**Yes**				No[a]			100%	**Yes**	300	310	No				No[a]				No[a]
Thallium	No	53%	**Yes**	2.5	0.1	**Yes**	6.7E+01	mg/kg	3.73E-02	No	4.92E-05	No	25%	**Yes**	0.025	0.400	No	2	ug/L	1.25E-02	No	1.64E-04	No	100%	**Yes**	0.08	0.07	**Yes**	6.7E+01	mg/kg	1.19E-03	No	1.80E-04	No	5.10E-02	No
Vanadium	No	100%	**Yes**	44.5	37.7	**Yes**	1.0E+03	mg/kg	4.45E-02	No	5.86E-05	No	0%	No	2.5	2.5	No	36	ug/L	6.94E-02	No	9.13E-04	No	100%	**Yes**	40.7	33.5	**Yes**	1.0E+03	mg/kg	4.07E-02	No	6.14E-03	No	1.55E-01	No
Zinc	No	71%	**Yes**	1078	103	**Yes**	1.0E+05	mg/kg	1.08E-02	No	1.42E-05	No	0%	No	5	5	No	11000	ug/L	4.55E-04	No	5.97E-06	No	100%	**Yes**	92	85	**Yes**	1.0E+05	mg/kg	9.20E-04	No	1.39E-04	No	1.22E-02	No
Cyanide	No	NA	No									No	NA	No										0%	No											No
								R_j =	759										**R_j =**	76										**R_j =**	7					
								N_{ij} =	20										**N_{ij} =**	21										**N_{ij} =**	19					
								$1/N_{ij}$ =	0.05										**$1/N_{ij}$ =**	0.05										**$1/N_{ij}$ =**	0.053					

Notes:

[a]Lower of EPA Region 9 Industrial Soil PRGs (EPA 2004a) and Washington MTCA Method A Industrial Soil Cleanup Levels (WDOE 2001b).

[b]Essential nutrient

[c]Lower of EPA Region 9 Tapwater PRGs (EPA 2004a) and Washington Drinking Water Quality Criteria, WAC 246-290-310 (WSDH 2006).

[d]Secondary contaminant that is generally limited to cosmetic or aesthetic effects, such as taste, odor, color, skin discoloration.

BG = Background
COI = Contaminant of interest
Conc = Concentration
COPC = Contaminant of potential concern
EPA = U.S. Environmental Protection Agency
MDC = Maximum detected concentration
NA = Not analyzed for
PRG = Preliminary remedation goal
mg/kg = Milligram per kilogram
ug/L = Microgram per liter

Analyzed for but not detected; value = 1/2 reporting limit.

Detected at concentration between the method detection limit and practical quantitation limt; value = reported concentration.

TABLE A.3
Exposure Factors
Sunset Mine and Millsite

Medium	Exposure Route	Parameter Code	Parameter Definition	Units	Adult Recreationalist			Child Recreationalist		
					RME Value	CTE Value	Reference	RME Value	CTE Value	Reference
All	All	BW	Body Weight	kg	70	70	EPA 1997a	15	15	EPA 1997a
		AT-C	Averaging Time (Cancer)	day	25,550	25,550	EPA 1989	25,550	25,550	EPA 1997a
		AT-N	Averaging Time (Non-Cancer)	day	10,950	3,285	365 x ED	2,190	2,190	365 x ED
		CF1	Conversion Factor	1 kg/mg	1E-06	1E-06		1E-06	1E-06	
		CF2	Conversion Factor	L/cm^3	1E-03	1E-03		1E-03	1E-03	
Mine Waste	Ingestion	IR-S	Incidental Ingestion Rate of Soil	mg/day	100	50	EPA 1997a	400	100	EPA 1997a
		EF	Exposure Frequency	day/year	14	7	(1)	14	7	(1)
		ED	Exposure Duration	years	30	9	(1)	6	6	(1)
	Dermal	SA	Skin Surface Area Available for Contact	cm^2	6,900	5,200	EPA 2004	5,000	4,500	EPA 2004
		DAF	Dermal Absorption Factor	--	CS	CS	EPA 2004	CS	CS	EPA 2004
		SSAF	Soil to Skin Adherence Factor	mg/cm^2-day	0.08	0.08	EPA 2004	1.00	0.3	EPA 2004
	Inhalation	IN	Inhalation Rate	m^3/day	15.2	15.2	EPA 1997a	8.3	8.3	EPA 1997a
		PEF	Particulate Emission Factor	m^3/kg	1.31E+09	1.31E+09	EPA 2000	1.31E+09	1.31E+09	EPA 2004
Sediment	Ingestion	IR-S	Incidental Ingestion Rate of Sediment	mg/day	50	25	EPA 1997a	200	50	EPA 1997a
		EF	Exposure Frequency	day/year	14	7	(1)	14	7	(1)
		ED	Exposure Duration	years	30	9	(1)	6	6	(1)
	Dermal	SA	Skin Surface Area Available for Contact	cm^2	5,700	5,700	EPA 2004	2,800	2,800	EPA 2004
		DAF	Dermal Absorption Factor[a]	unitless	CS	CS	EPA 2004	CS	CS	EPA 2004
		SSAF	Soil to Skin Adherence Factor	mg/cm^2/day	0.07	0.01	EPA 2004	0.20	0.04	EPA 2004
Surface Water	Ingestion	IR-W	Ingestion Rate of Surface Water	L/day	2.3	1.3	EPA 1997a	1.3	0.66	EPA 1997a
		EF	Exposure Frequency	day/year	14	7	(1)	14	7	(1)
		ED	Exposure Duration	years	30	9	(1)	6	6	(1)
	Dermal	SA	Skin Surface Area Available for Contact	cm^2	18,000	18,000	EPA 2004	6,000	6,000	EPA 2004
		KP	Permeability Coefficient	cm/hr	CS	CS	EPA 2004	CS	CS	EPA 2004
		EVF	Event Frequency	event/day	1	1		1	1	Site specific
		ET	Exposure Time	hr/day	2	2	EPA 1997a	2	2	EPA 1997a

Notes:

(1) Site-specific assumed value

EPA 1997a "Exposure Factors Handbook." Volumes I through III. Office of Research and Development. EPA/600/P-95/002Fa, -Fb, -Fc. August.

EPA 2004a "Region 9 Preliminary Remediation Goals (PRGs) Table." November 2004. On-line address: http://www.epa.gov/region9/waste/sfund/prg/whatsnew.htm.

EPA 2004b "Risk Assessment Guidance for Superfund, Part E, Supplemental Guidance for Dermal Risk Assessment." Volume I: Human Heath Evaluation Manual. Final. Office of Superfund Remediation and Technology Innovation. July.

CTE = Central tendency exposure
RME = Reasonable maximum exposure
cm/hr = Centimeter per hour
cm^2 = Square centimeter
hr/day = Hour per day
kg/gm = Kilogram per milligram
L/day = Liter per day
L/cm^3 = Liter per cubic centimeter
mg/cm^2-day = Milligram per square centimeter per day
mg/day = Milligram per day
m^3/day = Cubic meter per day
m^3/kg = Cubic meter per kilogram

TABLE A.4
Exposure Point Concentrations
Sunset Mine and Millsite

Contaminant of Potential Concern	Media	Artihmetic Mean	95% UCL[a]	Maximum Detected Concentration	Units	REASONABLE MAXIMUM EXPOSURE			CENTRAL TENDENCY EXPOSURE		
						Media EPC Value	Media EPC Statistic	Media EPC Rationale	Media EPC Value	Media EPC Statistic	Media EPC Rationale
Antimony	Mine Waste	30	261	400	mg/kg	261	99% Chebyshev mean	Non-parametric distribution	30.5	Mean	RAGS
	Surface Water	0.001	0.003	0.002	mg/L	0.002	Appx. Gamma UCL	Gamma distribution	0.001	Mean	RAGS
	Sediment	0.25		0.30	mg/kg	0.30	MDC	UCLs not computed	0.25	Mean	RAGS
Arsenic	Mine Waste	126	782	1,150	mg/kg	782	99% Chebyshev mean	Non-parametric distribution	126	Mean	RAGS
	Surface Water	0.002	0.003	0.003	mg/L	0.003	Student's t UCL	Normal distribution	0.002	Mean	RAGS
	Sediment	7.5		7.8	mg/kg	7.8	MDC	UCLs not computed	7.5	Mean	RAGS
Cadmium	Mine Waste	1.55	2.61	5.00	mg/kg	2.6	Appx. Gamma UCL	Gamma distribution	1.55	Mean	RAGS
	Surface Water	0.0001	0.0001	0.0001	mg/L	0.0001	Student's t UCL	Normal distribution	0.0001	Mean	RAGS
	Sediment	0.29		0.31	mg/kg	0.31	MDC	UCLs not computed	0.29	Mean	RAGS
Chromium	Mine Waste	16.2	21.0	59.0	mg/kg	21.0	Appx. Gamma UCL	Gamma distribution	16.2	Mean	RAGS
	Surface Water	0.005	0.005	0.005	mg/L	0.005	No detected results	All results below detection limit	0.005	Mean	RAGS
	Sediment	21.5		22.0	mg/kg	22.0	MDC	UCLs not computed	21.5	Mean	RAGS
Copper	Mine Waste	63,197	584,395	883,000	mg/kg	584,395	99% Chebyshev mean	Non-parametric distribution	63,197	Mean	RAGS
	Surface Water	0.143	0.171	0.212	mg/L	0.2	Student's t UCL	Normal distribution	0.14	Mean	RAGS
	Sediment	106		109	mg/kg	109	MDC	UCLs not computed	106	Mean	RAGS
Iron	Mine Waste	60,765	80,999	226,000	mg/kg	80,999	Appx. Gamma UCL	Gamma distribution	60,765	Mean	RAGS
	Surface Water	0.13	0.82	0.38	mg/L	0.38	99% Chebyshev mean	Non-parametric distribution	0.13	Mean	RAGS
	Sediment	21,450		21,600	mg/kg	21,600	MDC	UCLs not computed	21,450	Mean	RAGS
Lead	Mine Waste	140	280	788	mg/kg	280	Appx. Gamma UCL	Gamma distribution	140	Mean	RAGS
	Surface Water	0.0010	0.006	0.0028	mg/L	0.0028	99% Chebyshev mean	Non-parametric distribution	0.0010	Mean	RAGS
	Sediment	7.2		8.0	mg/kg	8.0	MDC	UCLs not computed	7.2	Mean	RAGS
Mercury	Mine Waste	1.0	1.7	5.7	mg/kg	1.7	Appx. Gamma UCL	Gamma distribution	1.0	Mean	RAGS
	Surface Water	0.000005	0.000005	0.000006	mg/L	0.00001	Student's t UCL	Normal distribution	0.000005	Mean	RAGS
	Sediment	0.023		0.025	mg/kg	0.025	MDC	UCLs not computed	0.023	Mean	RAGS

Notes:

[a]UCLs not computed for sediment because fewer than 4 samples

EPC = Exposure point concentration

MDC = Maximum detected concentration

RAGS = U.S. Environmental Protection Agency (EPA), 1991. "Risk Assessment Guidance for Superfund (RAGS): Volume 1, Human Health Evaluation Manual" (Part A), No. 9285.701A. Office of Solid Waste and Emergency Response, Washington, DC.

UCL = Upper confidence level

mg/kg = Milligram per kilogram

mg/L = Milligram per liter

Analyzed for but not detected; value = 1/2 reporting limit.

Detected at concentration between the method detection limit and practical quantitation limt; value = reported concentration.

TABLE A.5
Non-carcinogenic COPC Toxicity Values
Sunset Mine and Millsite

Contaminant of Potential Concern	CAS Number	Chronic RfD (mg/kg-d)			Dermal Absorption Factor	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Data Source
		Oral	Dermal	Inhalation				
Antimony	7440360	4.00E-04	8.00E-06	NA	0.001	Lung, heart, liver, kidney	3/0	IRIS/RAIS
Arsenic	7440382	3.00E-04	1.23E-04	NA	0.03	Skin, Nervous System, Cardiovascular System	1000/1	IRIS/RAIS
$Cadmium_{diet}$	7740439	1.00E-03	1.00E-05	NA	0.001	Kidneys	10/1	IRIS/RAIS
$Cadmium_{water}$	7740439	5.00E-04	5.00E-06	NA	0.001	Kidneys	10/1	IRIS/RAIS
Chromium	7440473	1.50E+00	NA	2.86E-05	0.001	GI Tract, Kidneys, Liver, Skin	100/10	IRIS/RAIS
Copper	7440508	3.70E-02	1.20E-02	NA	0.001	Central Nervous System	1/1	IRIS/RAIS
Iron	7439896	3.00E-01	NA	NA	0.001	Liver, Kidneys	--/--	RAIS
Mercury	7439976	3.00E-04	2.10E-05	8.57E-05	0.001	Kidney	30/1	IRIS/RAIS

Notes:
COPC = Contaminant of potential concern
IRIS = Integrated Risk Information System
NA = Not available
RAIS = Risk Assessment Information System
RfD = Reference dose
mg/kg-d = Milligram per kilogram per day

TABLE A.6
Carcinogenic COPC Toxicity Values
Sunset Mine and Millsite

Contaminant of Potential Concern	CAS Number	Slope Factor $(mg/kg\text{-}day)^{-1}$			Type of Cancer	Weight of Evidence/Cancer Guideline Description	Data Source
		Oral	Dermal	Inhalation			
Arsenic	7440382	1.50E+00	3.66E+00	1.51E+01	Skin, lung	A	IRIS
Cadmium	7440439	NA	NA	6.30E+00	Lung	B1	IRIS
Chromium	7440473	NA	NA	2.94E+02	Lung	A	IRIS

Notes:
A = Known human carcinogen
B1 = Probable human carcinogen
IRIS = Integrated Risk Information System
NA = Not available
mg/kg-day = Milligram per kilogram per day

TABLE A.7a
Non-carcinogenic Hazards - Adult Recreationalist
Sunset Mine and Millsite

Media	COPC	Chronic Reference Dose (mg/kg-day)			CENTRAL TENDENCY EXPOSURE SCENARIO								REASONABLE MAXIMUM EXPOSURE SCENARIO							
					CTE EPC (mg/kg); (mg/L)	Average Daily Dose (mg/kg-day)			Non-carcinogenic Hazard by Exposure Route			CTE Total Hazard	RME EPC (mg/kg); (mg/L)	Average Daily Dose (mg/kg-day)			Non-carcinogenic Hazard by Exposure Route			RME Total Hazard
		Oral	Dermal	Inhalation		Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation			Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation	
Mine Waste	Sb	4.0E-04	8.0E-06	NA	30	4E-07	3E-09	1E-10	0.001	0.0004		0.001	261	1E-05	8E-08	2E-09	0.04	0.01		0.05
	As	3.0E-04	1.2E-04	NA	126	2E-06	4E-07	4E-10	0.01	0.004		0.01	782	4E-05	7E-06	5E-09	0.1	0.06		0.2
	Cd_d	1.0E-03	1.0E-05	NA	1.55	2E-08	2E-10	5E-12	0.00002	0.00002		0.00004	2.61	1E-07	8E-10	2E-11	0.0001	0.00008		0.0002
	Cr	1.5E+00	NA	2.9E-05	16.2	2E-07	2E-09	5E-11	0.0000001		0.000002	0.000002	21.0	1E-06	6E-09	1E-10	0.000001		0.000005	0.000005
	Cu	3.7E-02	1.2E-02	NA	63197	9E-04	7E-06	2E-07	0.02	0.001		0.02	584395	3E-02	2E-04	4E-06	0.9	0.01		0.9
	Fe	3.0E-01	NA	NA	60765	8E-04	7E-06	2E-07	0.003			0.003	80999	4E-03	2E-05	5E-07	0.01			0.01
	Hg	3.0E-04	2.1E-05	8.6E-05	1.0	1E-08	1E-10	3E-12	0.00005	0.00001	0.00000004	0.0001	1.7	9E-08	5E-10	1E-11	0.0003	0.00002	0.0000001	0.0003
								Mine Waste CTE Subtotal =	**0.03**	**0.005**	**0.000002**	**0.04**				**Mine Waste RME Subtotal =**			**1**	**0.08**	**0.000005**	**1**
Sediment	Sb	4.0E-04	8.0E-06	NA	0.25	2E-09	4E-12		0.000004	0.0000005		0.000005	0	8E-09	7E-11		0.00002	0.000008		0.00003
	As	3.0E-04	1.2E-04	NA	7.5	5E-08	4E-09		0.0002	0.00003		0.0002	8	2E-07	5E-08		0.0007	0.0004		0.001
	Cd_d	1.0E-03	1.0E-05	NA	0.29	2E-09	4E-12		0.000002	0.0000004		0.000002	0.31	8E-09	7E-11		0.000008	0.000007		0.00002
	Cr	1.5E+00	NA	2.9E-05	21.5	1E-07	3E-10		0.0000001			0.0000001	22.0	6E-07	5E-09		0.0000004			0.0000004
	Cu	3.7E-02	1.2E-02	NA	106	7E-07	2E-09		0.00002	0.0000001		0.00002	109	3E-06	2E-08		0.00008	0.000002		0.00008
	Fe	3.0E-01	NA	NA	21450	1E-04	3E-07		0.0005			0.0005	21600	6E-04	5E-06		0.002			0.002
	Hg	3.0E-04	2.1E-05	8.6E-05	0.023	2E-10	4E-13		0.000001	0.00000002		0.000001	0	7E-10	5E-12		0.000002	0.0000003		0.000003
								Sediment CTE Subtotal =	**0.001**	**0.00003**		**0.001**				**Sediment RME Subtotal =**			**0.003**	**0.0004**		**0.003**
Surface Water	Sb	4.0E-04	8.0E-06	NA	0.001	4E-07	1E-08		0.001	0.001		0.002	0.0	3E-06	5E-08		0.008	0.006		0.01
	As	3.0E-04	1.2E-04	NA	0.002	8E-07	2E-08		0.003	0.0002		0.003	0.0	4E-06	6E-08		0.01	0.0005		0.01
	Cd_w	5.0E-04	5.0E-06	NA	0.0001	4E-08	1E-09		0.0001	0.0002		0.0003	0.000	1E-07	2E-09		0.0003	0.0004		0.0006
	Cr	1.5E+00	NA	2.9E-05	0.005	2E-06	1E-07		0.000001			0.000001	0.01	6E-06	2E-07		0.000004			0.000004
	Cu	3.7E-02	1.2E-02	NA	0.1	5E-05	1E-06		0.001	0.0001		0.001	0.2	2E-04	3E-06		0.006	0.0003		0.006
	Fe	3.0E-01	NA	NA	0.13	5E-05	1E-06		0.0002			0.0002	0.38	5E-04	7E-06		0.002			0.002
	Hg	3.0E-04	2.1E-05	8.6E-05	0.000	2E-09	5E-11		0.00001	0.000002		0.00001	0.00	7E-09	1E-10		0.00002	0.000005		0.00003
								Surface Water CTE Subtotal =	**0.004**	**0.0005**		**0.005**				**Surface Water RME Subtotal =**			**0.02**	**0.001**		**0.02**
								Total CTE Non-carcinogenic Hazard =	**0.04**	**0.005**	**0.000002**	**0.04**				**Total RME Non-carcinogenic Hazard =**			**1**	**0.08**	**0.000005**	**1**

Notes:

COPC = Contaminant of potential concern

CTE = Central tendency exposure

EPC = Exposure point concentration

RME = Reasonable maximum exposure

mg/kg-day = Milligram per kilogram per day

mg/kg = Milligram per kilogram

mg/L = Milligram per liter

TABLE A.7b
Non-carcinogenic Hazards - Child Recreationalist
Sunset Mine and Millsite

					CENTRAL TENDENCY EXPOSURE SCENARIO								REASONABLE MAXIMUM EXPOSURE SCENARIO							
		Chronic Reference Dose (mg/kg-day)			CTE EPC (mg/kg); (mg/L)	Average Daily Dose (mg/kg-day)			Non-carcinogenic Hazard by Exposure Route			CTE Total Hazard	RME EPC (mg/kg); (mg/L)	Average Daily Dose (mg/kg-day)			Non-carcinogenic Hazard by Exposure Route			RME Total Hazard
Media	COPC	Oral	Dermal	Inhalation		Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation			Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation	
Mine Waste	Sb	4.0E-04	8.0E-06	NA	30	4E-06	5E-08	2E-10	0.01	0.007		0.02	261	3E-04	3E-06	4E-09	0.7	0.4		1
	As	3.0E-04	1.2E-04	NA	126	2E-05	7E-06	1E-09	0.05	0.05		0.1	782	8E-04	3E-04	1E-08	**3**	2		5
	Cd_d	1.0E-03	1.0E-05	NA	1.55	2E-07	3E-09	1E-11	0.0002	0.0003		0.0005	2.61	3E-06	3E-08	4E-11	0.003	0.003		0.006
	Cr	1.5E+00	NA	2.9E-05	16.2	2E-06	3E-08	1E-10	0.000001		0.000005	0.00001	21.0	2E-05	3E-07	3E-10	0.00001		0.00001	0.00003
	Cu	3.7E-02	1.2E-02	NA	63197	8E-03	1E-04	5E-07	0.2	0.009		0.2	584395	6E-01	7E-03	9E-06	**16**	0.6		17
	Fe	3.0E-01	NA	NA	60765	8E-03	1E-04	5E-07	0.03			0.03	80999	8E-02	1E-03	1E-06	0.3			0.3
	Hg	3.0E-04	2.1E-05	8.6E-05	1.0	1E-07	2E-09	8E-12	0.0004	0.00008	0.0000001	0.0005	1.7	1.7E-06	2.1E-08	2.7E-11	0.006	0.001	0.0000003	0.007
					Mine Waste CTE Subtotal =				**0.3**	**0.1**	**0.000005**	**0.4**	**Mine Waste RME Subtotal =**				**20**	**3**	**0.00001**	**23**
Sediment	Sb	4.0E-04	8.0E-06	NA	0.25	2E-08	4E-11		0.00004	0.000004		0.00004	0.30	2E-07	4E-10		0.0004	0.00005		0.0004
	As	3.0E-04	1.2E-04	NA	7.5	5E-07	3E-08		0.002	0.0003		0.002	7.8	4E-06	3E-07		0.01	0.003		0.02
	Cd_d	1.0E-03	1.0E-05	NA	0.29	2E-08	4E-11		0.00002	0.000004		0.00002	0.31	2E-07	4E-10		0.0002	0.00004		0.0002
	Cr	1.5E+00	NA	2.9E-05	21.5	1E-06	3E-09		0.000001			0.000001	22	1E-05	3E-08		0.00001			0.000008
	Cu	3.7E-02	1.2E-02	NA	106	7E-06	2E-08		0.0002	0.000001		0.0002	109	6E-05	2E-07		0.002	0.00001		0.002
	Fe	3.0E-01	NA	NA	21450	1E-03	3E-06		0.005			0.005	21600	1E-02	3E-05		0.04			0.04
	Hg	3.0E-04	2.1E-05	8.6E-05	0.023	1E-09	3E-12		0.000005	0.0000002		0.000005	0.03	1E-08	4E-11		0.00004	0.000002		0.00004
					Sediment CTE Subtotal =				**0.01**	**0.0003**		**0.007**	**Sediment RME Subtotal =**				**0.05**	**0.003**		**0.06**
Surface Water	Sb	4.0E-04	8.0E-06	NA	0.0012	1E-06	2E-08		0.002	0.002		0.005	0.002	8E-06	7E-08		0.02	0.009		0.03
	As	3.0E-04	1.2E-04	NA	0.0024	2E-06	4E-08		0.007	0.0003		0.007	0.003	1E-05	9E-08		0.03	0.0007		0.03
	Cd_w	5.0E-04	5.0E-06	NA	0.0001	8E-08	2E-09		0.0002	0.0003		0.0005	0.0001	3E-07	3E-09		0.0007	0.0006		0.001
	Cr	1.5E+00	NA	2.9E-05	0.005	4E-06	2E-07		0.000003			0.000003	0.005	2E-05	3E-07		0.00001			0.00001
	Cu	3.7E-02	1.2E-02	NA	0.14	1E-04	2E-06		0.003	0.0002		0.003	0.17	6E-04	5E-06		0.02	0.0004		0.02
	Fe	3.0E-01	NA	NA	0.13	1E-04	2E-06		0.0004			0.0004	0.38	1E-03	1E-05		0.004			0.004
	Hg	3.0E-04	2.1E-05	8.6E-05	0.000	4E-09	7E-11		0.00001	0.000003		0.00002	0.00001	2E-08	2E-10		0.00006	0.000008		0.00007
					Surface Water CTE Subtotal =				**0.01**	**0.003**		**0.02**	**Surface Water RME Subtotal =**				**0.1**	**0.01**		**0.1**
					Total CTE Non-carcinogenic Hazard =				**0.3**	**0.1**	**0.000005**	**0.4**	**Total RME Non-carcinogenic Hazard =**				**20**	**3**	**0.00001**	**23**

Notes:

COPC = Contaminant of potential concern

CTE = Central tendency exposure

EPC = Exposure point concentration

RME = Reasonable maximum exposure

mg/kg-day = Milligram per kilogram per day

mg/kg = Milligram per kilogram

mg/L = Milligram per liter

TABLE A.8a
Carcinogenic Risks - Adult Recreationalist
Sunset Mine and Millsite

Media	COPC	Cancer Slope Factor (mg/kg-day)$^{-1}$			CENTRAL TENDENCY EXPOSURE SCENARIO								REASONABLE MAXIMUM EXPOSURE SCENARIO							
					CTE EPC (mg/kg); (mg/L)	Average Daily Dose (mg/kg-day)			Carcinogenic Risk by Exposure Route			CTE Total Risk	RME EPC (mg/kg); (mg/L)	Average Daily Dose (mg/kg-day)			Carcinogenic Risk by Exposure Route			RME Total Risk
		Oral	Dermal	Inhalation		Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation			Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation	
Mine Waste	As	1.5E+00	3.7E+00	1.5E+01	126	2E-07	6E-08	5E-11	3E-07	2E-07	8E-10	5E-07	782	2E-05	3E-06	2E-09	**3E-05**	**1E-05**	3E-08	**4E-05**
	Cd_d	NA	NA	6.3E+00	1.5	3E-09	2E-11	6E-13			4E-12	4E-12	2.6	6E-08	3E-10	7E-12			4E-11	4E-11
	Cr_{VI}	NA	NA	2.9E+02	16.2	3E-08	2E-10	7E-12			2E-09	2E-09	21.0	5E-07	3E-09	6E-11			2E-08	2E-08
								Mine Waste CTE Subtotal =	**3E-07**	**2E-07**	**3E-09**	**5E-07**				**Mine Waste RME Subtotal =**	**3E-05**	**1E-05**	**5E-08**	**4E-05**
Sediment	As	1.5E+00	3.7E+00		7.5	7E-09	5E-10		1E-08	2E-09		1E-08	7.8	9E-08	2E-08		1E-07	8E-08		2E-07
	Cd_d	NA	NA		0.29	3E-10	6E-13						0.31	4E-09	3E-11					
	Cr_{VI}	NA	NA		21.5	2E-08	4E-11						22.0	3E-07	2E-09					
								Sediment CTE Subtotal =	**1E-08**	**2E-09**		**1E-08**				**Sediment RME Subtotal =**	**1E-07**	**8E-08**		**2E-07**
Surface Water	As	1.5E+00	3.7E+00		0.002	1E-07	3E-09		2E-07	1E-08		2E-07	0.003	2E-06	3E-08		**2E-06**	9E-08		**3E-06**
	Cd_w	NA	NA		0.0001	5E-09	1E-10						0.0001	5E-08	8E-10					
	Cr_{VI}	NA	NA		0.005	2E-07	1E-08						0.005	3E-06	8E-08					
								Surface Water CTE Subtotal =	**2E-07**	**1E-08**		**2E-07**				**Surface Water RME Subtotal =**	**2E-06**	**9E-08**		**3E-06**
								Total CTE Carcinogenic Risk =	**5E-07**	**2E-07**	**3E-09**	**7E-07**				**Total RME Carcinogenic Risk =**	**3E-05**	**1E-05**	**5E-08**	**4E-05**

Notes:
COPC = Contaminant of potential concern
CTE = Central tendency exposure
EPC = Exposure point concentration
RME = Reasonable maximum exposure
mg/kg-day = Milligram per kilogram per day
mg/kg = Milligram per kilogram
mg/L = Milligram per liter

TABLE A.8b
Carcinogenic Risks - Child Recreationalist
Sunset Mine and Millsite

					CENTRAL TENDENCY EXPOSURE SCENARIO								REASONABLE MAXIMUM EXPOSURE SCENARIO							
		Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$			CTE EPC (mg/kg); (mg/L)	Average Daily Dose (mg/kg-day)			Carcinogenic Risk by Exposure Route			CTE Total Risk	RME EPC (mg/kg); (mg/L)	Average Daily Dose (mg/kg-day)			Carcinogenic Risk by Exposure Route			RME Total Risk
Media	COPC	Oral	Dermal	Inhalation		Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation			Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation	
Mine Waste	As	1.5E+00	3.7E+00	1.5E+01	126	1E-06	6E-07	9E-11	**2E-06**	**2E-06**	1E-09	**4E-06**	782	7E-05	3E-05	1E-09	**1E-04**	**9E-05**	2E-08	**2E-04**
	Cd_d	NA	NA	6.3E+00	1.5	2E-08	2E-10	1E-12			7E-12	7E-12	2.6	2E-07	3E-09	4E-12			2E-11	2E-11
	Cr_{VI}	NA	NA	2.9E+02	16.2	2E-07	2E-09	1E-11			3E-09	3E-09	21.0	2E-06	2E-08	3E-11			9E-09	9E-09
								Mine Waste CTE Subtotal =	**2E-06**	**2E-06**	**5E-09**	**4E-06**					**Mine Waste RME Subtotal =**	**1E-04**	**9E-05**	**2E-08**	**2E-04**
Sediment	As	1.5E+00	3.7E+00		7.5	4E-08	3E-09		6E-08	1E-08		7E-08	7.8	3E-07	3E-08		5E-07	1E-07		6E-07
	Cd_d	NA	NA		0.29	2E-09	3E-12						0.31	1E-08	4E-11					
	Cr_{VI}	NA	NA		21.5	1E-07	3E-10						22.0	1E-06	3E-09					
								Sediment CTE Subtotal =	**6E-08**	**1E-08**		**7E-08**					**Sediment RME Subtotal =**	**5E-07**	**1E-07**		**6E-07**
Surface Water	As	1.5E+00	3.7E+00		0.002	2E-07	3E-09		3E-07	1E-08		3E-07	0.003	9E-07	8E-09		1E-06	3E-08		1E-06
	Cd_w	NA	NA		0.0001	7E-09	1E-10						0.0001	3E-08	3E-10					
	Cr_{VI}	NA	NA		0.005	4E-07	1E-08						0.005	1E-06	3E-08					
								Surface Water CTE Subtotal =	**3E-07**	**1E-08**		**3E-07**					**Surface Water RME Subtotal =**	**1E-06**	**3E-08**		**1E-06**
								Total CTE Carcinogenic Risk =	**2E-06**	**2E-06**	**5E-09**	**4E-06**					**Total RME Carcinogenic Risk =**	**1E-04**	**9E-05**	**2E-08**	**2E-04**

Notes:

COPC = Contaminant of potential concern

CTE = Central tendency exposure

EPC = Exposure point concentration

RME = Reasonable maximum exposure

mg/kg-day = Milligram per kilogram per day

mg/kg = Milligram per kilogram

mg/L = Milligram per liter

TABLE A.9

Summary of Human Health Non-carcinogenic Hazards and Carcinogenic Risks

Sunset Mine and Millsite

Media and Exposure Pathway	CENTRAL TENDENCY EXPOSURE				REASONABLE MAXIMUM EXPOSURE			
	NON-CARCINOGENIC HAZARD		CARCINOGENIC RISK		NON-CARCINOGENIC HAZARD		CARCINOGENIC RISK	
	Recreationalist Adult	Recreationalist Child	Recreationalist Adult	Recreationalist Child	Recreationalist Adult	Recreationalist Child	Recreationalist Adult	Recreationalist Child
Mine Waste:								
Ingestion	0.03	0.3	3.E-07	**2.E-06**	1	**20**	**3.E-05**	**1.E-04**
Dermal	0.005	0.07	2.E-07	**2.E-06**	0.1	**3**	**1.E-05**	**9.E-05**
Inhalation	0.000002	0.000005	3.E-09	5.E-09	0.000005	0.00001	5.E-08	2.E-08
Subtotal =	0.04	0.4	5.E-07	**4.E-06**	1	**23**	**4.E-05**	**2.E-04**
Sediment:								
Ingestion	0.001	0.006	1.E-08	6.E-08	0.003	0.05	1.E-07	5.E-07
Dermal	0.00003	0.0003	2.E-09	1.E-08	0.0004	0.003	8.E-08	1.E-07
Subtotal =	0.001	0.007	1.E-08	7.E-08	0.003	0.06	2.E-07	6.E-07
Surface Water								
Ingestion	0.004	0.01	2.E-07	3.E-07	0.02	0.07	**2.E-06**	1.E-06
Dermal	0.001	0.003	1.E-08	1.E-08	0.001	0.01	9.E-08	3.E-08
Subtotal =	0.005	0.02	2.E-07	3.E-07	0.02	0.08	**3.E-06**	1.E-06
TOTAL =	0.04	0.4	7.E-07	**4.E-06**	1	**23**	**4.E-05**	**2.E-04**

Pathway Totals:

Ingestion	0.04	0.3	5.E-07	**2.E-06**	1	**20**	**3.E-05**	**1.E-04**
Dermal	0.005	0.07	2.E-07	**2.E-06**	0.08	**3**	**1.E-05**	**9.E-05**
Inhalation	0.000002	0.000005	3.E-09	5.E-09	0.000005	0.00001	5.E-08	2.E-08

Notes:

Bold values exceed risk screening levels

APPENDIX B

ECOLOGICAL RISK CALCULATION TABLES

TABLE B.1
Preliminary Contaminant of Potential Ecological Concern Screening - Mine Waste
Sunset Mine and Millsite
(results reported in mg/kg)

Analyte	Minimum Detected Concentration	Maximum Detected Concentration	95% UCL[a]	Essential Nutrient?	Retain For Screening?	Detection Frequency	Retain for Screening?	Average Background Concentration[b]	Retain for Risk-based Screening?
Silver	0.015	268	83.4	No	**Yes**	94%	**Yes**	0.63	**Yes**
Aluminum	4170	22400	14472	No	**Yes**	100%	**Yes**	14633	**Yes**
Arsenic III	0.14	0.5	0.37	No	**Yes**	100%	**Yes**	0.04	**Yes**
Arsenic V	2.5	133	78.8	No	**Yes**	100%	**Yes**	10.9	**Yes**
Arsenic Total	0.15	1150	782	No	**Yes**	94%	**Yes**	11.0	**Yes**
Barium	8.4	111.0	55.2	No	**Yes**	100%	**Yes**	82.9	**Yes**
Beryllium	0.1	1.0	0.62	No	**Yes**	35%	**Yes**	0.13	**Yes**
Cadmium	0.03	5	2.6	No	**Yes**	47%	**Yes**	0.54	**Yes**
Cobalt	2.5	26.0	15.4	No	**Yes**	94%	**Yes**	7.0	**Yes**
Chromium III	NA	NA	NA	No	No	NA	No	13.6	No
Chromium VI	0.38	103.6	104	No	**Yes**	40%	**Yes**	0.5	**Yes**
Chromium Total	5	59	21	No	**Yes**	100%	**Yes**	14.7	**Yes**
Copper	2420	883000	584395	No	**Yes**	100%	**Yes**	348	**Yes**
Iron	16700	226000	80999	Yes	**Yes**	100%	**Yes**	16000	**Yes**
Mercury	0.03	5.74	1.7	No	**Yes**	94%	**Yes**	0.06	**Yes**
Manganese	92	1400	841	No	**Yes**	100%	**Yes**	243	**Yes**
Nickel	0	30	17.5	No	**Yes**	53%	**Yes**	13.0	**Yes**
Lead	0.11	788	280	No	**Yes**	100%	**Yes**	8.7	**Yes**
Antimony	1	400	261	No	**Yes**	18%	**Yes**	0.23	**Yes**
Selenium	0.3	50	26.2	No	**Yes**	29%	**Yes**	1.08	**Yes**
Thallium	0.13	2.5	2.5	No	**Yes**	53%	**Yes**	0.06	**Yes**
Vanadium	8	44.5	31	No	**Yes**	100%	**Yes**	38	**Yes**
Zinc	0.5	1078	265	No	**Yes**	71%	**Yes**	103	**Yes**
Calcium	100	13400	5278	Yes	No	100%	No	2287	No
Potassium	1020	2530	1986	Yes	No	100%	No	492	No
Magnesium	1400	9250	6134	Yes	No	100%	No	4207	No
Sodium	30	210	109	Yes	No	100%	No	153	No
Cyanide	NA	NA	NA	No	No	NA	No	NA	No

Notes:

[a]If the calculated 95% UCL was greater than the maximum detected concentration (MDC), the MDC was used.

[b]The average concentration was used because there were not enough background samples to calculate the 95% UCL.

NA = Not analyzed for

UCL = Upper confidence limit

mg/kg = Milligram per kilogram

Analyzed for but not detected; value = 1/2 reporting limit.

Detected at concentration between the method detection limit and practical quantitation limt; value = reported concentration.

Calculated value

TABLE B.2
Preliminary Contaminant of Potential Ecological Concern Screening - Surface Water
Sunset Mine and Millsite
(results reported in mg/L)

Analyte	Minimum Detected Concentration	Maximum Detected Concentration	95% UCL[a]	Essential Nutrient?	Retain for Screening?	Detection Frequency	Retain for Screening?	Average Background Concentration[b]	Retain for Risk-based Screening?
Silver	0.000025	0.00026	0.00026	No	**Yes**	25%	**Yes**	0.00005	**Yes**
Aluminum	0.03	0.27	0.27	No	**Yes**	100%	**Yes**	0.05	**Yes**
Arsenic III	0.000004	0.00013	0.00011	No	**Yes**	88%	**Yes**	0.00006	**Yes**
Arsenic V	0.00070	0.0032	0.0030	No	**Yes**	63%	**Yes**	0.0002	**Yes**
Arsenic Total	0.0007	0.0033	0.0030	No	**Yes**	88%	**Yes**	0.0002	**Yes**
Barium	0.011	0.020	0.019	No	**Yes**	88%	**Yes**	0.003	**Yes**
Beryllium	0.001	0.001	0.001	No	**Yes**	0%	No	0.001	No
Cadmium	0.0001	0.0001	0.0001	No	**Yes**	38%	**Yes**	0.0001	No
Cobalt	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Chromium III	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Chromium VI	0.0005	0.0005	0.0005	No	**Yes**	0%	No	0.0005	No
Chromium Total	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Copper	0.091	0.21	0.17	No	**Yes**	75%	**Yes**	0.0005	**Yes**
Iron	0.005	0.38	0.38	Yes	No	75%	No	0.02	No
Mercury	0.000004	0.000006	0.000005	No	**Yes**	100%	**Yes**	0.0000005	**Yes**
Manganese	0.0025	0.013	0.013	No	**Yes**	13%	**Yes**	0.0025	**Yes**
Nickel	0.005	0.005	0.005	No	**Yes**	0%	**No**	0.005	No
Lead	0.00005	0.0028	0.0028	No	**Yes**	38%	**Yes**	0.0004	**Yes**
Antimony	0.0005	0.0024	0.0024	No	**Yes**	38%	**Yes**	0.0002	**Yes**
Selenium	0.0005	0.0005	0.0005	No	**Yes**	0%	No	0.0001	**Yes**
Thallium	0.000025	0.000025	0.00003	No	**Yes**	25%	**Yes**	0.0004	No
Vanadium	0.0025	0.0025	0.003	No	**Yes**	0%	No	0.0025	No
Zinc	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Calcium	9.8	20.4	19.7	Yes	No	100%	No	1.8	No
Potassium	0.4	0.8	0.7	Yes	No	88%	No	0.15	No
Magnesium	1	2.6	2.4	Yes	No	100%	No	0.3	No
Sodium	1.4	2.8	2.7	Yes	No	100%	No	0.70	No

Notes:

[a]If the calculated 95% UCL was greater than the maximum detected concentration (MDC), the MDC was used.

[b]The average concentration was used because there were not enough background samples to calculate the 95% UCL.

UCL = Upper confidence limit

mg/L = Milligram per liter

Analyzed for but not detected; value = 1/2 reporting limit.

Detected at concentration between the method detection limit and practical quantitation limt; value = reported concentration.

TABLE B.3
Preliminary Contaminant of Potential Ecological Concern Screening - Sediment
Sunset Mine and Millsite
(results reported in mg/kg)

Analyte	Minimum Detected Concentration	Maximum Detected Concentration	95% UCL[a]	Essential Nutrient?	Retain for Screening?	Detection Frequency	Retain for Screening?	Maximum Detected Background Concentration[b]	Retain for Risk-based Screening?
Silver	0.07	0.17	0.17	No	**Yes**	100%	**Yes**	0.68	No
Aluminum	11800	11800	11800	No	**Yes**	100%	**Yes**	11100	**Yes**
Arsenic III	0.018	0.019	0.019	No	**Yes**	25%	**Yes**	0.02	No
Arsenic V	7.17	7.76	7.76	No	**Yes**	100%	**Yes**	8	**Yes**
Arsenic Total	7.2	7.8	7.8	No	**Yes**	100%	**Yes**	8	**Yes**
Barium	67.2	79.9	79.9	No	**Yes**	100%	**Yes**	69.2	No
Beryllium	0.1	0.1	0.1	No	**Yes**	0%	No	0.1	No
Cadmium	0.26	0.31	0.31	No	**Yes**	100%	**Yes**	0.36	No
Cobalt	8	9	9	No	**Yes**	100%	**Yes**	7	**Yes**
Chromium III	NA	NA	NA	No	**Yes**	NA	**Yes**	NA	No
Chromium VI	NA	NA	NA	No	**Yes**	NA	**Yes**	NA	No
Chromium Total	21	22	22	No	**Yes**	100%	**Yes**	20	**Yes**
Copper	102	109	109	No	**Yes**	100%	**Yes**	84	**Yes**
Iron	21300	21600	21600	Yes	No	100%	No	17500	No
Mercury	0.02	0.025	0.025	No	**Yes**	0%	No	0.03	No
Manganese	548	555	555	No	**Yes**	100%	**Yes**	475	**Yes**
Nickel	20.6	27.8	27.8	No	**Yes**	100%	**Yes**	17.4	**Yes**
Lead	6.4	8.0	8.0	No	**Yes**	100%	**Yes**	4.78	**Yes**
Antimony	0.2	0.3	0.3	No	**Yes**	100%	**Yes**	0.10	**Yes**
Selenium	0.25	0.25	0.25	No	**Yes**	0%	No	0.25	No
Thallium	0.07	0.08	0.08	No	**Yes**	100%	**Yes**	0.07	**Yes**
Vanadium	38.9	40.7	40.7	No	**Yes**	100%	**Yes**	33.5	**Yes**
Zinc	77	92	92	No	**Yes**	100%	**Yes**	85	**Yes**
Calcium	2600	2940	2940	Yes	No	100%	No	2640	No
Cyanide	0.2	0.2	0.2	No	**Yes**	0%	No	0.20	No
Potassium	1500	1680	1680	Yes	No	100%	No	1270	No
Magnesium	6480	7780	7780	Yes	No	100%	No	5660	No
Sodium	260	300	300	Yes	No	100%	No	310	No

Notes:

[a]If the calculated 95% UCL was greater than the maximum detected concentration (MDC), the MDC was used.

[b]The maximum concentration was used because there was only a single background sample.

NA = Not analyzed for

UCL = Upper confidence limit

Analyzed for but not detected; value = 1/2 reporting limit.

Detected at concentration between the method detection limit and practical quantitation limt; value = reported concentration.

TABLE B.4
Preliminary Contaminant of Potential Ecological Concern Screening - Pore Water
Sunset Mine and Millsite
(results reported in mg/L)

Analyte	Minimum Detected Concentration	Maximum Detected Concentration	95% UCL[a]	Essential Nutrient?	Retain for Screening?	Detection Frequency	Retain for Screening?	Maximum Detected Background Concentration[b]	Retain for Risk-based Screening?
Silver	0.000025	0.000025	0.000025	No	**Yes**	0%	No	0.000025	No
Aluminum	0.015	0.015	0.015	No	**Yes**	0%	No	0.015	No
Arsenic III	0.000017	0.000022	0.000022	No	**Yes**	75%	**Yes**	0.000045	No
Arsenic V	0.00018	0.00018	0.00018	No	**Yes**	100%	**Yes**	0.00026	No
Arsenic Total	0.0002	0.0002	0.0002	No	**Yes**	100%	**Yes**	0.0003	No
Barium	0.003	0.004	0.004	No	**Yes**	100%	**Yes**	0.004	No
Beryllium	0.001	0.001	0.001	No	**Yes**	0%	No	0.001	No
Cadmium	0.00005	0.00005	0.00005	No	**Yes**	0%	No	0.00005	No
Cobalt	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Chromium III	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Chromium VI	0.00001	0.00001	0.00001	No	**Yes**	100%	**Yes**	0.00001	No
Chromium Total	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Copper	0.0011	0.0016	0.0016	No	**Yes**	100%	**Yes**	0.0007	**Yes**
Iron	0.005	0.005	0.005	Yes	No	0%	No	0.005	No
Mercury	0.00000052	0.0000006	0.0000006	No	**Yes**	100%	**Yes**	0.0000004	**Yes**
Manganese	0.0025	0.0025	0.0025	No	**Yes**	0%	No	0.0025	No
Nickel	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Lead	0.00005	0.00005	0.00005	No	**Yes**	0%	No	0.00005	No
Antimony	0.0001	0.0001	0.0001	No	**Yes**	0%	No	0.0001	No
Selenium	0.00005	0.00005	0.00005	No	**Yes**	0%	No	0.00005	No
Thallium	0.000025	0.000025	0.000025	No	**Yes**	0%	No	0.000025	No
Vanadium	0.0025	0.0025	0.0025	No	**Yes**	0%	No	0.0025	No
Zinc	0.005	0.005	0.005	No	**Yes**	0%	No	0.005	No
Calcium	1.7	2.9	2.9	Yes	No	0%	No	1.7	No
Potassium	0.15	0.15	0.15	Yes	No	0%	No	0.15	No
Magnesium	0.2	0.5	0.5	Yes	No	100%	No	0.3	No
Sodium	0.005	0.005	0.005	Yes	No	0%	No	0.01	No
Cyanide	0.000005	0.000005	0.000005	No	**Yes**	0%	No	0.000005	No

Notes:

[a]If the calculated 95% UCL was greater than the maximum detected concentration (MDC), the MDC was used.

[b]The maximum concentration was used because there was only a single background sample.

mg/L = Milligram per liter

Analyzed for but not detected; value = 1/2 reporting limit.

Detected at concentration between the method detection limit and practical quantitation limt; value = reported concentration.

TABLE B.5
Chemistry Toxicity Screening - Mine Waste
Sunset Mine and Millsite
(results reported in mg/kg)

			SCREENING LEVEL VALUE[d]				SINGLE COI RISK RATIO (T_{ij} = EPC/SLV)				RISK TO RECEPTORS? (Tij >1)[f] OR (T_{ij} > 5)[g]				CPEC?	MULTIPLE COI RISK RATIO ($T_{mult} = T_{ij}/T_j$)				MULTIPLE COI RISK TO RECEPTORS? (T_{ij}/T_j) > ($1/N_{ij}$)[f] or > ($5/N_{ij}$)[g]				CPEC?	Bioaccumulator CPEC?[h]
Analyte[a]	EPC (MDC)[b]	EPC (95% UCL)[c]	Plant	Invertebrate	Bird	Mammal	Plant	Invertebrate	Bird	Mammal	Plant[f]	Invertebrate[g]	Bird[f]	Mammal[f]		Plant	Invertebrate	Bird	Mammal	Plant[f]	Invertebrate[g]	Bird[f]	Mammal[f]		
Silver	268	83.4	2.0	50	NS	NS	134	5	-	-	**Yes**	**Yes**	No	No	**Yes**	0.00416	0.00028	-	-	No	No	No	No	**Yes**[e]	**Yes**
Aluminum	22400	14472	50	600	450	107	448	37	50	209	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	0.01390	0.00197	0.01157	0.08339	No	No	No	**Yes**	**Yes**	No
Arsenic III	0.5	0.365	10	60	10	7	0.1	0.01	0.1	0.1	No	No	No	No	No	0.00000	0.00000	0.00001	0.00003	No	No	No	No	No	No
Arsenic V	133	78.8	10	60	132	132	13	2	1.01	1.01	**Yes**	No	**Yes**	**Yes**	**Yes**	0.00041	0.00012	0.00023	0.00040	No	No	No	No	No	No
Arsenic Total	1150	782	NS	NS	NS	NS	-	-	-	-	No	No	No	No	**Yes**[e]	-	-	-	-	No	No	No	No	**Yes**[e]	No
Barium	111	55.2	500	3000	85	102	0.2	0.04	1.3	1.1	No	No	**Yes**	**Yes**	**Yes**	0.00001	0.00000	0.00030	0.00043	No	No	No	No	No	No
Beryllium	1	0.62	10	NS	NS	83	0.1	-	-	0.01	No	No	No	No	**Yes**[e]	0.00000	-	-	0.00000	No	No	No	No	**Yes**[e]	No
Cadmium	5.00	2.61	4	20	14	125	1.3	0.3	0.4	0.04	**Yes**	No	No	No	**Yes**	0.00004	0.00001	0.00008	0.00002	No	No	No	No	No	No
Cobalt	26.0	15.4	20	1000	NS	150	1.3	0.03	-	0.2	**Yes**	No	No	No	**Yes**	0.00004	0.00000	-	0.00007	No	No	No	No	**Yes**[e]	No
Chromium III	NA	NA																							
Chromium VI	103.6	103.6	NS	NS	NS	410	-	-	-	0.3	No	No	No	No	**Yes**[e]	-	-	-	0.00010	No	No	No	No	**Yes**[e]	No
Chromium Total	59	21	42	42	67	NS	1.4	1.4	0.9	-	**Yes**	No	No	No	**Yes**	0.00004	0.00007	0.00020	-	No	No	No	No	**Yes**[e]	No
Copper	883000	584395	100	50	217	390	8830	17660	4069	2264	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	0.27393	0.93361	0.94604	0.90191	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
Iron	226000	80999	10	200	NS	NS	22600	1130	-	-	**Yes**	**Yes**	No	No	**Yes**	0.70112	0.05974	-	-	**Yes**	No	No	No	**Yes**	**Yes**
Mercury	5.74	1.65	0.3	0.1	5.5	73	19	57	1.04	0.08	**Yes**	**Yes**	**Yes**	No	**Yes**	0.00059	0.00303	0.00024	0.00003	No	No	No	No	No	**Yes**
Manganese	1400	841	1100	100	4125	1500	1.3	14	0.3	0.9	**Yes**	**Yes**	No	No	**Yes**	0.00004	0.00074	0.00008	0.00037	No	No	No	No	No	No
Nickel	30	17.5	30	200	980	625	1.00	0.2	0.03	0.05	**Yes**	No	No	No	**Yes**	0.00003	0.00001	0.00001	0.00002	No	No	No	No	No	No
Lead	788	279.5	50	500	118	4000	16	1.6	7	0.2	**Yes**	No	**Yes**	No	**Yes**	0.00049	0.00008	0.00155	0.00008	No	No	No	No	No	No
Antimony	400	261	5	NS	NS	15	80	-	-	27	**Yes**	No	No	**Yes**	**Yes**	0.00248	-	-	0.01062	No	No	No	No	**Yes**[e]	**Yes**
Selenium	50	26.2	1	70	0.3	25	50	0.7	167	2	**Yes**	No	**Yes**	**Yes**	**Yes**	0.00155	0.00004	0.03875	0.00080	No	No	No	No	No	No
Thallium	2.50	2.5	1	NS	NS	1	3	-	-	3	**Yes**	No	No	**Yes**	**Yes**	0.00008	-	-	0.00100	No	No	No	No	**Yes**[e]	No
Vanadium	44.5	31	2	NS	47	25	22	-	0.9	1.8	**Yes**	No	No	**Yes**	**Yes**	0.00069	-	0.00022	0.00071	No	No	No	No	**Yes**[e]	No
Zinc	1078	265	86	200	360	20000	13	5	3	0.05	**Yes**	**Yes**	**Yes**	No	**Yes**	0.00039	0.00028	0.00070	0.00002	No	No	No	No	No	No
						Sum of T_{ij} (T_j) =	32234	18916	4301	2510														
						# of COIs (N_{ij}) =	20	16	14	18														
						$1/N_{ij}$ =	0.05	0.06	0.07	0.06														
						$5/N_{ij}$ =	0.25	0.31	0.36	0.28														

Notes:
[a]Contaminants retained after preliminary screening (essential nutrient, detection frequency, and background concentration comparison).
[b]The EPC used for plant and invertebrate receptors is the maximum detected concentration.
[c]The EPC used for bird and mammal receptors is the 95% upper confidence limit.
[d]SLVs are from WDOE WAC-173-340, Table 749-3 (2001c), where available; otherwise taken from ODEQ Guidance for Ecological Risk Assessment, Level II Screening Level Values (2001).
[e]Retained because of the lack of an SLV.
[f]A screening risk ratio of 1 was used for protected species.
[g]A screening risk ratio of 5 was used for non-protected species.
[h]Bioaccumulator CPECs (silver, cadmium, mercury, antimony, and iron) were retained if they posed risk to single or multiple risk receptor groups, not retained due to lack of SLV.
COI = Contaminant of interest
CPEC = Contaminant of potential ecological concern
EPC = Exposure point concentration
MDC = Maximum detected concentration
NA = Not analyzed for
NS = No SLV
ODEQ = Oregon Department of Environmental Quality
SLV = Screening level value
WDOE = Washington Department of Ecology
mg/kg = Milligram per kilogram

TABLE B.6
Chemistry Toxicity Screening - Surface Water
Sunset Mine and Millsite
(results reported in mg/L)

		SCREENING LEVEL VALUE[b,d]			SINGLE COI RISK RATIO (T_{ij} = EPC/SLV)			RISK TO RECEPTORS? (T_{ij}>1)[c]			CPEC?	MULTIPLE COI RISK RATIO (T_{ij}/T_j)			MULTIPLE COI RISK TO RECEPTORS (T_{ij}/T_i) > ($1/N_{ij}$)			CPEC?
Analyte[a]	**EPC (95% UCL)**	**Aquatic Life**	**Bird**	**Mammal**	**Aquatic Life**	**Bird**	**Mammal**	**Aquatic Life**	**Birds**	**Mammals**		**Aquatic Life**	**Bird**	**Mammal**	**Aquatic Life**	**Bird**	**Mammal**	
Silver	0.00026	0.00012	NS	NS	2	-	-	**Yes**	No	No	**Yes**	0.04	-	-	No	No	No	**Yes**[e]
Aluminum	0.27	0.087	797	8	3	0.0003	0.03	**Yes**	No	No	**Yes**	0.05	0.3	0.8	No	**Yes**	**Yes**	**Yes**
Arsenic III	0.00011	0.15	18	6	0.001	0.00001	0.00002	No	No	No	No	0.00001	0.01	0.0005	No	No	No	No
Arsenic V	0.00295	0.15	NS	NS	0.02	-	-	No	No	No	**Yes**[e]	0.0003	-	-	No	No	No	**Yes**[e]
Arsenic Total	0.00299	190	NS	NS	0.00002	-	-	No	No	No	**Yes**[e]	0.0000003	-	-	No	No	No	**Yes**[e]
Barium	0.0187	0.004	150	39	5	0.0001	0.0005	**Yes**	No	No	**Yes**	0.08	0.1	0.01	No	No	No	No
Cadmium	0.0001	0.00042	10	8	0.2	0.00001	0.00001	No	No	No	No	0.004	0.009	0.0003	No	No	No	No
Copper	0.171	0.004	341	53	42	0.001	0.003	**Yes**	No	No	**Yes**	0.7	0.5	0.08	**Yes**	**Yes**	No	**Yes**
Mercury	0.0000053	0.000012	3	10	0.4	0.000002	0.0000005	No	No	No	No	0.008	0.002	0.00001	No	No	No	No
Manganese	0.013	0.12	7242	676	0.1	0.000002	0.00002	No	No	No	No	0.002	0.002	0.0005	No	No	No	No
Lead	0.0028	0.00064	28	323	4	0.0001	0.000009	**Yes**	No	No	**Yes**	0.08	0.09	0.0002	No	No	No	No
Antimony	0.0024	NS	NS	1	-	-	0.002	No	No	No	**Yes**[e]	-	-	0.06	No	No	No	**Yes**[e]
				Sum of T_{ij} (T_j) =	57	0.0011	0.040											
				# COIs (N_{ij}) =	11	8	9											
				$1/N_{ij}$ =	0.09	0.13	0.11											
				$5/N_{ij}$ =	0.45	0.63	0.56											

Notes:

[a]Contaminants retained after preliminary screening (essential nutrient, detection frequency, and background concentration comparison).

[b]SLVs corrected for hardness and dissolved fraction where applicable.

[c]A screening risk ratio of 1 was used because of threatened and endangered species.

[d]SLVs are from WDOE Chronic AmbientFreshwater Criteria, WAC-173-201A (2003b), where available; otherwise taken from ODEQ Guidance for Ecological Risk Assessment, Level II Screening Level Values (2001).

[e]Retained because of the lack of SLVs.

COI = Contaminant of interest

CPEC = Contaminant of potential ecological concern

EPC = Exposure point concentration

NS = No SLV

ODEQ = Oregon Department of Environmental Quality

SLV = Screening level value

UCL = Upper confidence limit

WDOE = Washington Department of Ecology

mg/L = Milligram per liter

TABLE B.7
Chemistry Toxicity Screening - Sediment
Sunset Mine and Millsite
(results reported in mg/kg)

		SCREENING LEVEL VALUE[d]		SINGLE COI RISK RATIO (T_{ij} = EPC/SLV)		RISK TO RECEPTORS (T_{ij}>1)[c]		
Analyte[a]	EPC (95% UCL)	Freshwater Sediment	Bioaccumulation	Freshwater Sediment	Bioaccumulation	Freshwater Sediment	Bioaccumulation	CPEC?
Aluminum	11800	NS	NS	-	-	No	No	**Yes**[b]
Arsenic V	8	NS	NS	-	-	No	No	**Yes**[b]
Arsenic Total	8	20	NS	0.4	-	No	No	**Yes**[b]
Barium	80	NS	NS	-	-	No	No	**Yes**[b]
Cobalt	9.0	NS	NS	-	-	No	No	**Yes**[b]
Chromium Total	22.0	95	4200	0.2	0.005	No	No	No
Copper	109	80	10	1.4	11	**Yes**	**Yes**	**Yes**
Manganese	555	NS	1100	-	0.5	No	No	**Yes**[b]
Nickel	27.8	60	316	0.5	0.09	No	No	No
Lead	8.0	335	128	0.02	0.06	No	No	No
Antimony	0.3	0.4	10	0.8	0.03	No	No	**Yes**
Thallium	0.08	NS	0.7	-	0.1	No	No	**Yes**[b]
Vanadium	40.7	NS	NS	-	-	No	No	**Yes**[b]
Zinc	92.0	140	3	0.7	31	No	**Yes**	**Yes**

Notes:

[a]Contaminants retained after preliminary screening (essential nutrient, detection frequency, and background concentration comparison).

[b]Retained because of the lack of SLVs.

[c]A screening risk ratio of 1 was used because of threatened and endangered species.

[d]SLVs are from WDOE WAC-173-201A-230, Recommended Freshwater Sediment Quality Values (2004) where available; otherwise taken from ODEQ Guidance for Ecological Risk Assessment, Level II Screening (2001).

CPEC = Contaminant of potential ecological concern

EPC = Exposure point concentration

NS = No SLV

ODEQ = Oregon Department of Environmental Quality

SLV = Screening level value

UCL = Upper confidence limit

WDOE = Washington Department of Ecology

mg/kg = Milligram per kilogram

TABLE B.8
Chemistry Toxicity Screening - Pore Water
Sunset Mine and Millsite
(results reported in mg/L)

Analyte[a]	EPC (MDC)	AQUATIC LIFE						
		SCREENING LEVEL VALUE[b]	SINGLE COI RISK RATIO (T_{ij})	RISK TO RECEPTORS (T_{ij}>1)	CPEC?	MULTIPLE COI RISK RATIO (T_{ij}/T_i)	RISK TO RECEPTORS (T_{ij}/T_i) > ($1/N_{ij}$)	CPEC?
Copper	0.002	0.004	0.4	No	No	0.89	No	No
Mercury	0.000001	0.000012	0.05	No	No	0.11322	No	No
		Sum of T_{ij} (T_j) =	0					
		# COIs (N_{ij}) =	2					
		$1/N_{ij}$ =	0.50					

Notes:

[a]Contaminants retained after preliminary screening (essential nutrient, detection frequency, and background concentration comparison).

[b]SLVs are from WDOE Chronic Ambient Freshwater Criteria, WAC-173-201A (2003b), where available; otherwise taken from ODEQ Guidance for Ecological Risk Assessment, Level II Screening Level Values (2001).

COI = Contaminant of interest

CPEC = Contaminant of potential ecological concern

EPC= Exposure point concentration

MDC = Maximum detected concentration

ODEQ = Oregon Department of Environmental Quality

SLV = Screening level value

WDOE = Washington Department of Ecology

mg/L = Milligram per liter

TABLE B.9
Chemistry Toxicity Screening - Multiple Media
Sunset Mine and Millsite

	Single COI Risk Ratio (T_{ij})				Multiple Media Risk Ratio (T_{ij}-mine waste + T_{ij}-surface water)		Risk to Receptor ($T_{ij\text{-combined}}$>1)		CPEC?
	Mine Waste		Surface Water						
Analyte[a]	**Bird**	**Mammal**	**Bird**	**Mammal**	**Bird**	**Mammal**	**Bird**	**Mammal**	
Silver	-	-	-	-	-	-	No	No	No
Aluminum	50	209	0.0003	0.03	50	209	**Yes**	**Yes**	**Yes**
Arsenic III	0.1	0.1	0.00001	0.00002	0.1	0.1	No	No	No
Arsenic V	1.01	1.01	-	-	1.01	1.01	**Yes**	**Yes**	**Yes**
Arsenic Total	-	-	-	-	-	-	No	No	No
Barium	1.3	1.1	0.0001	0.0005	1.3	1.1	**Yes**	**Yes**	**Yes**
Beryllium	-	0.01	-	-	-	0.01	No	No	No
Cadmium	0.4	0.04	0.00001	0.00001	0.4	0.04	No	No	No
Cobalt	-	0.2	-	-	-	0.2	No	No	No
Chromium III	-	-	-	-	-	-	No	No	No
Chromium VI	-	0.3	-	-	-	0.3	No	No	No
Chromium Total	0.9	-	-	-	0.9	-	No	No	No
Copper	4069	2264	0.001	0.003	4069	2264	**Yes**	**Yes**	**Yes**
Iron	-	-	-	-	-	-	No	No	No
Mercury	1.04	0.08	0.000002	0.0000005	1.04	0.08	**Yes**	No	**Yes**
Manganese	0.3	0.9	0.000002	0.00002	0.3	0.9	No	No	No
Nickel	0.03	0.05	-	-	0.03	0.05	No	No	No
Lead	7	0.2	0.0001	0.000009	7	0.2	**Yes**	No	**Yes**
Antimony	-	27	-	0.002	-	27	No	**Yes**	**Yes**
Selenium	167	2	-	-	167	2	**Yes**	**Yes**	**Yes**
Thallium	-	3	-	-	-	3	No	**Yes**	**Yes**
Vanadium	0.9	1.8	-	-	0.9	2	No	**Yes**	**Yes**
Zinc	3	0.05	-	-	3	0.05	**Yes**	No	**Yes**

Notes:

[a]Contaminants retained after preliminary screening (essential nutrient, detection frequency, and background concentration comparison).

COI = Contaminant of interest

CPEC = Contaminant of potential ecological concern

APPENDIX C

SUPPLEMENTAL LIST OF SENSITIVE PLANT AND ANIMAL SPECIES

Species of Concern
Mt. Baker Snoqualmie National Forest

Federal Threatened Species

Fisheries
***Oncorhynchus kisutch* (Coho Salmon):** Present in Trout Creek, but not observed. Present (Washington Department of Natural Resources 2006)
***Salvelinus confluentus* (Bull Trout):** Present in Trout Creek, but not observed. Present (Washington Department of Natural Resources 2006)
***Oncorhynchus tshawytscha* (Chinook Salmon):** Present in Trout Creek, but not observed. Present (Washington Department of Natural Resources 2006)
Birds
***Strix occidentalis* (Spotted Owl)**: Occurs in higher elevations of old growth forest, documented on the Mt. Baker Snoqualmie National Forest. Potentially Present
***Brachyramphus marmoratus* (Marbled Murrelet)**: Occurs seasonally in the western Cascade Mountains and Puget Sound, nesting in trees in the forested portion of the coast roughly 2km from the shoreline. Not on Site (US Fish and Wildlife Service 1997)
Mammals
***Lynx Canadenis* (Canada Lynx)**: Occurs only in the northern Cascade Mountains Not on Site (US Fish and Wildlife Service 2006a)
***Ursus arctos* (Grizzly Bear):** Recovery range is within the northern Cascades. Potentially Present (US Fish and Wildlife Service 2006c)

Federal Threatened and Endangered Plants
Western Washington
(Washington Native Plant Society 2006)

Arenaria paludicola (Marsh sandwort)
Castilleja levisecta (Golden Paintbrush)
Howellia aquatilis (Water howellia)
Lupinus sulphureus ssp.kincaidii *(*Kincaid's lupine)
Sidalcea nelsoniana (Nelson's checker-mallow)
Lomatium bradshawii (Bradshaw's desert parsley)

Federal Candidate Species

***Rana pretiosa* (Oregon Spotted Frog):** Occur in wetland habitats in forested landscapes within the western Cascade Mountains at elevations ranging from sea level to 5000 feet. Washington Endangered Species, Federal Candidate Species. Potentially Present (US Fish and Wildlife Service 2004b)

Federal Species of Concern

Fisheries
***Oncorhynchus clarki clarki* (Coastal Cutthroat)**: Occurs in small streams and headwater habitat where spawning and rearing occurs with small-scale migrations. Populations above Snoqualmie Falls are considered non-migratory. Present (US Fish and Wildlife Service 2006b)
Birds
***Falco peregrinus* (Peregrine Falcon):** Have distribution throughout Washington with several sightings in King County. Potentially Present (Pacific Biodiversity Institute 2000)
***Gulo gulo* (Wolverine):** Occur throughout the Cascade Mountains in Washington. Present (Washington Department of Natural Resources 2006)
***Contopus borealis* (Olive sided flycatcher)**: Western Washington is a core habitat. Present (US Fish and Wildlife Service 2001)
***Empidonax traillii* (Willow Flycatcher)**: Occurs throughout Washington, Oregon, and Idaho Present (Pacific Biodiversity Institute 2006b)
***Accipiter gentiles* (Northern Goshawk)**: Occurs in most forested regions of Washington, about 27% of the breeding population within the state occurs in the Western Cascade Mountains. Present (The Center for Biological Diversity 2006)
Mammals
***Martes oennanti* (Fisher)**: Washington has scattered individuals and are considered extirpated. Not on Site (US Fish and Wildlife Service 2004a)
***Myotis yumanensis* (Yuma myotis):** Occurs regular large concentrations in naturally occurring breeding areas and other communal roosts within western Washington. Potentially Present (Washington Department of Natural Resources 2006)
***Coryhorhinus townsendii townsendii* (Pacific Townsend's big-eared bat):** Occurs within western Washington. Potentially Present (Washington Department of Natural Resources 2006)
***Bufo boreas* (Western Toad):** Occurs at lower elevations west of the Cascades, and at higher elevations in the Cascades Present (Pacific Biodiversity Institute 2006a)

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