Human Health and Ecological Risk Assessment
Granite Creek Mines
Wallowa Whitman National Forest

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Natural Solutions for Water

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Wallowa-Whitman National Forest

Site Location: Granite Creek Mines
Wallowa Whitman National Forest
Grant County, Oregon

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Cover Photo: Monumental Mine Millsite.

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ACRONYMS

CEEM	conceptual ecological exposure model
COI	chemical of interest
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
ODEQ	Oregon Department of Environmental Quality
ERA	ecological risk assessment
ERBSC	ecological risk-based screening concentration
HHRA	human health risk assessment
PRG	Preliminary Remediation Goals
SI	Site Inspection
RTE	rare, threatened, or endangered
90UCL	90^{th} percentile upper confidence limit on the arithmetic mean
USEPA	United States Environmental Protection Agency
USFS	United States Department of Agriculture, Forest Service
WWNF	Wallowa Whitman National Forest

EXECUTIVE SUMMARY

- Potential human health and ecological risks associated with mining-related contamination at the Monumental, Cap Martin, Sheridan, Tillicum, and Central Mines (collectively referred to as the Granite Creek Mines) within the Granite Creek watershed (Site) were assessed through a streamlined risk assessment process.
  - The Site is located in the upper portion of the Granite Creek watershed, 5 to 8 miles north of Granite, Oregon in Grant County in the Wallowa Whitman National Forest.
  - The risk assessment process generally follows U.S. Environmental Protection Agency and Oregon Department of Environmental Quality guidelines.
- The following is a summary of the human health risk assessment:
  - Current and future potential receptors were identified as hunters, hikers, and campers.
  - Arsenic and lead were identified as the soil/wasterock, sediment, and surface water non-carcinogenic contaminants of potential concern (COPCs).
  - No unacceptable non-carcinogenic health effects are anticipated under both the central tendency exposure (CTE) and reasonable maximum exposure (RME) conditions.
  - Arsenic was the only carcinogenic COPC identified at the Site.
  - Carcinogenic risks were predicted from exposure to arsenic-impacted surface water and soil/wasterock under both the CTE and the RME exposure conditions.
  - No carcinogenic risks were predicted from exposure to sediment.
  - No hot spots were identified at the Site.
- The following is a summary of the ecological risk assessment
  - Ecological impacts were predicted for immobile species, primarily plants and terrestrial invertebrates, due to contaminants of potential ecological concern (COPECs) in soil and wasterock. Local and regional populations of these and other terrestrial species are unlikely to be significantly impacted.
  - Ecological impacts were also predicted for aquatic life and wildlife exposed to COPECs in surface water and pore water. However, the lack of background samples makes it more difficult to predict the potential for impacts.
  - Benthic invertebrates and wildlife appear to have the potential to be impacted by total arsenic, cadmium, and zinc, which are present at elevated concentrations at nearly all sediment sample locations. The lack of background sediment samples likely results in an overestimation of these potential impacts.
  - The Monumental and Tillicum Mines appear to have more locations with elevated COPEC concentrations in soil/wasterock than the other mines.
  - Multiple ecological hot spots were identified at nearly every mine.
- Based on the information presented in this report, CES recommends:
  - Performing an Engineering Evaluation / Cost Analysis (EECA) for the following reasons:
    - Unacceptable carcinogenic risks were predicted from exposure to arsenic in wasterock under the CTE and RME recreational exposure scenarios.
    - Ecological risks were predicted from exposure to multiple COPECs in all media.
    - Multiple ecological hot spots were identified in all media.
  - In addition, as part of the EECA, a data gap investigation should be completed to address multiple data gaps identified at the Site.

1.0 INTRODUCTION

- Potential human health and ecological risks associated with mining-related contamination at the Monumental, Cap Martin, Sheridan, Tillicum, and Central Mines (collectively referred to as the Granite Creek Mines) within the Granite Creek watershed (Site) were assessed through a streamlined risk assessment process.
- The Site is located in the upper portion of the Granite Creek watershed, 5 to 8 miles north of Granite, Oregon in Grant County in the Wallowa Whitman National Forest (WWNF).
- The risk assessment process follows Oregon Department of Environmental Quality (ODEQ) and U.S. Environmental Protection Agency (USEPA) guidelines.
- Potential risks and hazards were evaluated using Site-specific concentrations of chemicals of interest (COIs), selected human and ecological receptors and respective exposure pathways, and appropriate risk-based screening concentrations.

2.0 RISK ASSESSMENT DATA AND INITIAL SCREENING

- This section describes the data set used in this risk analysis and the initial screening for the human health risk assessment (HHRA) and ecological risk assessment (ERA).
- Data were selectively collected in areas where contamination was known or suspected to occur; therefore, the data set is skewed towards an understanding of the magnitude of contamination on Site rather than a full characterization of the Site.
- The data used in the risk assessment are from soil, vegetation, wasterock, surface water, pore water, and sediment samples collected during the Site Inspection (SI) conducted by EA Engineering, Science, and Technology, Inc. (EA) in January 2004 (EA, 2004). The following samples were collected from five mines within the watershed:
  - 4 background soil samples
  - 24 surface and subsurface wasterock samples
    - 14 surface soil samples for the HHRA at 0-1.5 feet below the ground surface [bgs]
    - 17 surface soil samples for the ERA at 0-3 feet bgs, and
    - 10 subsurface soil samples at greater than 1.5 feet bgs for the HHRA.
  - 4 background vegetation samples
  - 6 vegetation samples
  - 13 surface water samples
  - 11 pore water samples
  - 20 sediment samples
- Overall, the data are likely to overestimate the concentrations found across the Site because samples were located to represent the areas of highest COI concentrations, not areas representative of overall human and ecological receptor exposure at and surrounding the Site. This is a conservative approach that is appropriate for screening level risk assessments.
- Initially, all data collected during the SI and deemed appropriate for use in the risk assessment were used to calculate the 90^{th} percentile upper confidence level on the arithmetic mean (90UCL) for each medium:
  - The 90UCL is an upper-bound (i.e., conservative) estimate of mean chemical concentration and is specified as an appropriate exposure point concentration (EPC) in Oregon's Revised Cleanup Rules (OAR 340-122-084).
  - If fewer than 10 samples are available in a given medium, it is inappropriate to calculate a 90UCL (USEPA, 2003). In these cases, and if an appropriately calculated 90UCL exceeded the maximum detected concentration, the maximum detected concentrations were used as a substitute for the 90UCL.

- The data were screened using the ODEQ's *Guidance for Conduct of Deterministic Risk Assessments* (1998), which allows for prescreening of COIs based on the following criteria:
  - **Essential Nutrients:** calcium, magnesium, potassium, and sodium were removed from further assessment because they are considered to be essential nutrients.
  - **Frequency of Detection:** COIs in each medium that were detected in 5% or less of the samples Site-wide were removed from further assessment.
  - **Background:** 90UCL or maximum (as described above) concentrations of naturally-occurring chemicals that were present at concentrations less than maximum background concentrations were eliminated from further assessment.
- The results of these initial screening procedures for each potential exposure medium are also shown in Tables A-1 through A-7 in Appendix A.
- The tables in Appendix A depict sample reporting limit screening that shows which undetected chemicals have reporting limits that are below background concentrations and below the lowest applicable medium-specific risk-based screening concentrations. If a chemical did not meet this criterion, the COI was conservatively included for further assessment at one-half the maximum sample reporting limit.
- The selected COIs for the HHRA and ERA are shown in Table 2-1.

Table 2-1
Chemicals of Interest Remaining Following the Initial Screening

COIs	Soil/ Waste Material		Vegetation	Surface Water		Pore Water	Sediment	
	HHRA	ERA	ERA	HHRA	ERA	ERA	HHRA	ERA
Aluminum				X	X	X	X	X
Antimony	X	X					X	X
Arsenic, total	X	X	X	X	X	X	X	X
Barium	X	X		X	X	X	X	X
Beryllium			X				X	X
Cadmium	X	X	X				X	X
Chromium, total			X	X	X		X	X
Cobalt							X	X
Copper	X	X	X				X	X
Iron	X	X	X	X	X	X	X	X
Lead	X	X	X	X	X	X	X	X
Manganese	X	X		X	X	X	X	X
Mercury	X	X	X	X	X	X	X	X
Nickel							X	X
Selenium	X	X		X	X	X	X	X
Silver	X	X			X	X	X	X
Thallium	X	X		X		X	X	X
Vanadium	X	X	X				X	X
Zinc	X	X	X	X	X	X	X	X

X = COI selected for further screening

3.0 HUMAN HEALTH RISK ASSESSMENT

- A HHRA is an analysis of the potential adverse health effects that could result from current or future exposures to hazardous substances released from a site, in the absence of any action to control or mitigate these releases.

- The objective of this HHRA is to incorporate analytical data and information on potential human exposure to the COIs in order to provide a baseline assessment of the potential for human health risks to be realized due to Site-related contamination.
- The following are primary elements of the HHRA:
  - **Hazard Identification and Selection of Contaminants of Potential Concern:** Evaluation of Site data and identification of elevated concentrations of COIs in human exposure media, resulting in a list of contaminants of potential concern (COPCs) for the HHRA.
  - **Exposure assessment**: Identification of areas that pose human health risks under current or potential future site uses and conservative estimation of exposure.
  - **Toxicity assessment:** Quantification of the relationship between chemical exposure and adverse effects.
  - **Risk characterization:** Development of quantitative risk estimates using exposure and toxicity information previously developed for the COPCs.

3.1 HAZARD IDENTIFICATION AND SELECTION OF COPCS

- This section presents the rationale for the selection of the COPCs. Prescreening of the COIs was described in Section 2.0.
- The media of interest for human health included soil, wasterock, surface water, and sediment.
- Those COIs that were retained for further assessment following the initial screening are shown in the last column of Tables A-1, A-2, A-4, and A-6 for surface soil, subsurface soil, surface water (including one adit water sample), and sediment, respectively.
- Maximum concentrations of these COIs were screened against USEPA Region IX Preliminary Remediation Goals (PRGs).
  - Industrial PRGs were selected as most appropriate screening criteria for soils and sediment.
  - Tap water PRGs represent a very conservative screen for surface water.
  - Table B-1 present the PRG screening and results.
- Arsenic and lead were identified as COPCs for the Site.

3.2 EXPOSURE ASSESSMENT

Assessing the exposure at a given site includes the identification of potentially exposed populations, the selection of relevant exposure pathways, and the calculation of exposure point concentrations and chronic daily intakes.

3.2.1 Potentially Exposed Population

- The Site consists of five mines located within the Granite Creek watershed. Maps and figures of the Site are provided in the SI report (EA, 2004). The following is a brief summary of the rational for the potentially exposed population:

  <u>Monumental Mine</u>
  - The Monumental Mine, located near the headwaters of Granite Creek, includes two open adits, a shaft, three settling ponds, three wasterock piles, and a former mill site. Access to the mine is by way of FR 7345.
  - The mine is situated on moderate to steep hillsides at the headwaters of Granite Creek.
  - Water flows from an upper seep into a series of three settling ponds, all of which are connected by surface water flow. In addition, water seeps from the lower adit through a constructed ditch to the lower settling pond. No outlet for the settling pond was observed during SI activities.

Cap Martin Mine

- The Cap Martin Mine is situated approximately 1.4 miles downstream from the headwaters of Granite Creek and contains two observed collapsed adits, one additional reported adit, three wasterock piles, and an outwash fan from the south wasterock pile.
- The mine is located on moderately steep hillsides on both sides of Granite Creek and is accessed via FR 7345.

Sheridan Mine

- The Sheridan Mine is located about 0.40 miles downstream of the Cap Martin Mine, east of the bank of an unnamed tributary of Granite Creek.
- The mine includes two possible adits, one of which is collapsed at the portal and contains a seep that discharges into a marshy area.
- One wasterock pile is located downgradient from the collapsed adit.
- The mine is situated on moderately steep slopes on the south side of Granite Creek and is accessed via FR 7345.

Tillicum Mine

- The Tillicum Mine is located along Granite Creek, approximately 0.25 miles downstream of the Sheridan Mine and contains two collapsed adits and associated wasterock piles, and reportedly several additional adits.
- No water was observed flowing from the adits during SI field activities.
- The mine is situated on moderately steep slopes along the north bank of Granite Creek and is accessed via FR 7345.

Central Mine

- The Central Mine is located about 0.6 miles downstream of the Tillicum Mine, southeast of the intersection of FR 73 (Elkhorn Drive Scenic Byway) and FR 7345.
- The mine contains two observed adits and one reported adit; water was not observed flowing from the adits during the SI field investigation.
- Three wasterock piles are located at the mine.
- A wasterock berm, created as a result of hydraulic mining activities, runs in east-west direction about 75 to 100 feet upslope of Granite Creek.
- The mine is situated on a moderately steep slope north of Granite Creek.

- Given the types of human uses expected, the potential for long-term exposure to Site-related contaminants is considered low.
- There are no onsite workers, or occupied structures, on the Site or within 200 feet of the Site.
- Access is currently not restricted by fencing, nor were any “No Trespassing” signs observed.
- In general, land uses in this area are limited to recreation (hiking, fishing, camping, hunting, etc.) and possibly some minerals prospecting on nearby claims.
- The ingestion, dermal contact, and air exposure pathways are considered complete, because hikers, hunters, and campers have the potential to access the Site.
- The most likely pathway of exposure at the Site is inhalation of particulates.
- Fish consumption was eliminated as a potential pathway of concern because, with the exception of tribal fishing, all recreational fishing in Granite Creek and its tributaries was prohibited by the Oregon Department of Fish and Wildlife (ODFW) in 1997 (EA, 2004). The number and size of fish present also severely limits any potential for a recreational or subsistence fishing scenario.

3.2.2 Identification of Potential Exposure Pathways

- The conceptual human exposure model is presented in Figure 3-1.
- Exposures to COPCs were evaluated for all complete pathways for which there was a receptor. These pathways were determined to be:
  - Inhalation of soil/wasterock particulates;
  - Dermal contact with surface water, sediment, and soil/wasterock; and
  - Incidental ingestion of surface water, sediment, and soil/wasterock.

3.2.3 Current and Potential Future Receptors

- The Site is not currently occupied, nor is it expected to be occupied in the future.
- The only likely current and future receptors are hikers, campers, and hunters.

3.2.4 Exposure Assumptions

- Exposure assumptions include factors such as body weight, averaging time, exposure frequency, exposure duration, and chemical bioavailability.
- Separate assumptions are made for both average or central tendency exposure (CTE) and reasonable maximum exposure (RME).
- In general, CTE represents a less conservative model of the Site risk, using exposure factors that are more indicative of the average recreational user rather than a maximally exposed user.
- The exposure factors and assumptions used in this risk assessment are presented in Table B-2 in Appendix B.

3.2.5 Exposure Point Concentrations

- An EPC is used in coordination with the exposure factors to calculate the Average Daily Dose (ADD) of a COPC.
- The EPC can be the maximum concentration detected or a statistical average.
- It is not reasonable to assume long-term contact with the maximum concentration.
- When sufficient data exists, an upper-bound estimate of average concentrations (i.e., the 90UCL) is used because an average concentration is most representative of the concentration contacted over this time period.
- As per the USEPA (1997), when data for a particular exposure medium were limited to less than 10 samples, the maximum detected concentration was used as the EPC. Where the data set contained greater than 10 samples, 90UCL was calculated and used as the EPC.
- The EPCs are presented in Table 3-1 and Table B-3 in Appendix B.

Table 3-1
Exposure Point Concentrations

COPC	N	Maximum	Central Tendency Exposure[1]	Reasonable Maximum Exposure[2]	Comments
Surface Soil (milligrams per kilogram[mg/kg])					
Total Arsenic	14	11400	1870	3446	90UCL
Sediment (mg/kg)					
Total Arsenic	20	303	58.5	88.5	90UCL
Surface Water (milligrams per liter [mg/L])					
Total Arsenic	13	0.0818	0.0115	0.0232	90UCL

[1] Average concentration

[2] 90UCL if greater then 10 datapoints; Maximum concentration if less than 10 datapoints

n = Number of samples

EPC = Exposure point concentration

UCL = Upper confidence Limit

3.2.6 Exposure Doses

- The EPCs are then entered into exposure dose calculations to calculate the ADD of a contaminant for each receptor type.
- While presented individually in the equations, USEPA Region X allows for the calculation of Summary Intake Factors (Intake Factors) as follows:
  - Intake Factors represent the sum lifetime exposure to contaminated soil, water, or air through the pathway. The Intake Factors are presented in Table B-4.
  - Dermal absorption factors are required to calculate dermal exposures to surface water and these are shown in Tables B-5 and B-6.
  - The Intake Factors, when multiplied by the EPC, provide the ADD for each chemical.

3.3 TOXICITY ASSESSMENT

- The purpose of the toxicity assessment is to present the critical toxicity values for the COPCs. Toxicity is defined as the ability of a chemical to induce adverse effects at some dosage in biological systems.
- The purpose of the toxicity assessment is twofold:
  - To identify the carcinogenic (cancer) and non-carcinogenic (non-cancer) effects that may arise from direct or indirect exposure of humans to the COPCs; and
  - To provide an estimate of the quantitative relationship between the magnitude and duration of exposure, and the probability or severity of adverse effects.

3.3.1 Toxicity Values

- Toxicity values are used to quantitatively describe the relationship between the extent of exposure to a COPC and the potential increased likelihood, or severity, of adverse effects.
- Where toxicity values are available, the following sources have been used:
  - Integrated Risk Information System (IRIS) computer database (USEPA, 2004)
  - Health Effects Assessment Summary Table (HEAST) (USEPA, 1997)

- Both carcinogenic and non-carcinogenic effects were quantitatively evaluated as noted below:
  - The endpoints for these two different types of effects are assessed differently because the mechanisms by which chemicals cause cancer are assumed to be fundamentally different from the processes that cause non-carcinogenic effects.
  - The principal difference reflects the assumption that non-carcinogenic effects are assumed to exhibit a threshold dose below which no adverse effects occur, where USEPA assumes no such threshold exists for carcinogenic effects.
  - Because exposure to some chemicals may result in both carcinogenic and non-carcinogenic effects, both endpoints associated with a COPC were evaluated quantitatively when sufficient toxicity data are available.

3.3.2 Categorization of Chemicals as Non-Carcinogens or Carcinogen

- Chemicals are classified as those that cause cancer (carcinogens) and those that cause other, non-cancer, health effects (non-carcinogens).
- The methods for assessing the potential for these two different types of health effects are different. Where a chemical can cause cancer and non-cancer health effects, the risk evaluation calculates the potential for both types of effects.
- The following sections provide background information on the toxicity values for carcinogenic and non-carcinogenic chemicals, how they are determined, and how they are used in the risk analysis.

3.3.2.1 Potential Adverse Non-carcinogenic Health Effect

- The following summarizes the purpose and usage of reference doses (RfDs):
  - Reference doses are critical toxicity factors for chemicals that can cause non-carcinogenic health effects.
  - An RfD represents an estimated intake rate that is unlikely to produce measurable adverse effects over a lifetime of exposure (USEPA, 1989a).
  - RfDs are determined by the USEPA RfD Work Group or from the health effects assessment documents developed by the USEPA Office of Research and Development.
  - An RfD, expressed in units of milligrams per kilogram per day (mg/kg-day), assumes a threshold for adverse non-carcinogenic effects. An ADD below the RfD is considered unlikely to cause adverse health effects.
  - RfDs are route-specific; that is, RfDs may be different for ingestion, inhalation, or other routes of exposure.
  - RfDs are derived using uncertainty factors (UFs) and modifying factors (MFs).
  - The Critical Toxicity Factors for the non-carcinogenic COPCs are presented in Table 3-2 and B-7 in Appendix B.

Table 3-2
Critical Toxicity Values for the Non-carcinogenic COPCs

COPC	Oral Chronic Reference Dose* (mg/kg-day)	Confidence in Reference Dose	Endpoint
Arsenic	0.0003	Medium	hyperpigmentation, vascular

* Reference Dose value from Region IX PRG Tables

3.3.2.2 Potential Carcinogenic Effects

- Carcinogenic toxicity is not assumed to have a threshold concentration below which adverse effects do not occur; therefore, carcinogenic risk from exposure to a COPC is expressed in terms of the probability that an exposed receptor will develop cancer over their lifetime.
- Contaminant-specific dose response curves are used to establish slope factors (SFs) that represent an upper-bound excess cancer risk from a lifetime exposure.
- Dose response curves for human carcinogens are developed from tumorgenic and laboratory studies; the SF is generated from the 90UCL of the extrapolated dose curve using probabilistic methods and represents a conservative upper-bound estimate of the potential risk associated with exposure.
- Based on USEPA guideline documents, critical toxicity data for arsenic and chromium are presented in Table 3-3 and B-8 in Appendix B (refer to USEPA 1999 for additional information).

Table 3-3
Critical Toxicity Values for the Carcinogenic COPCs

COPC	Slope Factor (mg/kg/day)-1		Weight of Evidence Classification*	Type of cancer	Basis of Slope Factor
	Oral	Inhalation	Ingestion/Inhalation	Ingestion/ Inhalation	Oral/Inhalation
Arsenic	1.5E+00	1.5E+01	A	Skin	Epidemiologic Studies

A = Known human carcinogen

3.3.2.3 Lead Critical Toxicity Values

- Meaningful oral and inhalation critical toxicity values have not been developed for lead.
- Many of the non-carcinogenic effects associated with lead may not exhibit a threshold, especially in young children.
- USEPA considers lead to be a B2 carcinogen. In lieu of a reference dose or slope factor, USEPA has developed the Integrated Exposure Uptake/Biokinetic Model (IEUBK) and the Adult Lead Model (ALM) which correlate dose with blood lead levels.
- The Federal Action Level for Lead in drinking water is 0.015 mg/L (USEPA, 2002).
- Lead exposure levels are as follows:
  - The lowest-observed adverse effect level (LOAEL) of lead is considered to be 10 micrograms per deciliter (µg/dl) in children and fetuses and 30 µg/dl in adults.
  - Empirically-derived ratios of 0.16 and 0.04 µg/dl per µg/day ingested by children and adults respectively, recommended by USEPA (1986) are used to predict concentrations in young children and adults.
  - Applying an uncertainty factor of 10 results in provisional tolerable intake levels of 6 µg/day for children six or less, 15 µg/day for children over six, 25 µg/day for pregnant women and 75 µg/day for men.

3.4 RISK CHARACTERIZATION

- Potential human health impacts associated with exposure to COPCs at the Site were evaluated by estimating the potential for both non-carcinogenic and carcinogenic health effects.
- The following sections discuss the assessment of non-carcinogenic hazards, carcinogenic risks, and lead risk associated with exposure to COPCs at the Site.

- The sampling locations were selected as locations where levels of concentrations were suspected to be the highest. This type of sampling identifies the worst-case situations and is intended to be a conservative data set that is sufficient for the specific purposes of risk assessment.

3.4.1 Non-Carcinogenic Hazard Assessment

- Non-carcinogenic hazard is estimated as the ratio of the ADD of the non-carcinogenic chemical through a specific exposure route to the chronic (or subchronic) RfD for that exposure route.
- For example, intakes from the ingestion route are compared to oral RfDs.
- The assessment is completed as follows:
  - The ADD divided by the RfD for an individual chemical is termed the Hazard Quotient (HQ).
  - HQs greater than 1.0 indicate the potential for adverse health effects because the intake exceeds the RfD (USEPA, 1986b).
  - An HQ is calculated for each chemical that elicits a non-carcinogenic health effect if an RfD is available for the chemical and exposure route.
  - The sum of all individual chemical-specific HQs is termed the Hazard Index (HI) and is calculated under each exposure pathway.
  - The HI considers exposure to a mixture of chemicals having non-carcinogenic effects based on the assumption that the effects of chemical mixtures are additive (USEPA, 1986b).
  - An HI greater than 1.0 indicates the potential for adverse non-carcinogenic effects. When the HI is greater than 1.0, the USEPA guidance allows for segregating HIs by critical effect categories. Major categories of critical effects include neurotoxicity, developmental effects, and effects on target organs to name a few.

3.4.2 Excess Cancer Risk Assessment

- Carcinogenic risk is an estimate of the probability that a COPC will produce a carcinogenic effect.
- The excess lifetime carcinogenic risk is the incremental increase in the probability of developing cancer compared to the background incremental probability of developing cancer with no exposure to Site contaminants.
- An excess cancer risk (ECR) of 1×10^{-6}, represents an increase of one additional case of cancer (above background) in one million people exposed to a carcinogen over their lifetime (70 years).
- Estimates of carcinogenic risk using the slope factors developed by USEPA are generally upper-bound estimates. Actual risks from exposures to chemical constituents at the Sites would likely be lower than the risks estimated herein.
- For estimating carcinogenic risk from exposure to more than one carcinogenic chemical from a single exposure route, risks from each individual chemical are summed to estimate total ECR.

3.4.3 Potential Non-carcinogenic Hazards and Excess Cancer Risks

3.4.3.1 Discussion of Non-carcinogenic Hazards

- Soils/Wasterock
  - Arsenic and lead were identified as COPCs (Table B-9).
  - Arsenic is the only COPC that can be quantitatively evaluated.
  - The average concentration and the 90UCL concentration were used as the EPC.
  - None of the individual constituents exceeded the ODEQ regulatory standard of 1.0 under CTE and RME exposure conditions.

- Sediments
  - Arsenic and lead were identified as the COPCs.
  - The HQs are below the ODEQ regulatory standard of 1.0 for both the RME and CTE exposure scenarios.
- Surface water
  - Arsenic and lead were identified as COPCs.
  - The HQs are below the ODEQ regulatory standard of 1.0 for both the RME and CTE exposure scenarios.

3.4.3.2 Discussion of Potential Excess Cancer Risks

- Soil/Wasterock
  - The only carcinogenic constituent identified was arsenic (Appendix B, Table B-10).
  - The average concentration and the 90UCL concentration were used as the EPCs for the CTE and RME exposures, respectively.
  - The ECRs exceeded the ODEQ standard of 1×10^{-6} under both CTE and RME exposure conditions.
  - For the CTE exposure conditions, ECRs for ingestion (2×10^{-6}) did not exceed the EPA risk range of 1×10^{-4} to 1×10^{-6} but did exceed the ODEQ regulatory standard of 1×10^{-6}.
  - For the RME exposure condition, ECRs for ingestion (2×10^{-5}) and dermal contact (2×10^{-5}) did not exceed the EPA risk range of 1×10^{-4} to 1×10^{-6} but did exceed ODEQ regulatory standard of 1×10^{-6}.
  - Inhalation of particulates did not exceed the ODEQ regulatory standard 1×10^{-6} under both CTE and RME exposure conditions.
  - A carcinogenic risk is possible from exposure to arsenic impacted soil/wasterock under the CTE and the RME exposure scenarios.
- Sediments
  - The only carcinogenic constituent identified in sediment is arsenic.
  - The ECRs for arsenic in sediment did not exceed the ODEQ regulatory standard 1×10^{-6} under both CTE and RME exposure conditions.
- Surface Water
  - The only carcinogenic constituent identified in surface water is arsenic.
  - The ECRs for arsenic in surface water exceeded the ODEQ regulatory standard of 1×10^{-6} under both the CTE and the RME exposure conditions for both ingestion and dermal contact.
  - A carcinogenic risk is possible from exposure to arsenic impacted surface water under the CTE and the RME exposure scenarios.

3.4.3.3. Estimation of Potential Human Health Impacts from Exposure to Lead

- The USEPA's lead models simulate soil lead exposures at a single location. Two models have been developed, the IEUBK model and the ALM:
  - These models require a minimum of three months of continuous exposure of at least one day per week.
  - Three months exposure is the minimum to produce a quasi-steady-state lead concentration.
  - The reliability of the models for predicting lead concentrations for exposure durations shorter than three months has not been assessed.
  - In order to address non-continuous exposures, the USEPA Office of Solid Waste and Emergency Response (OSWER) has developed a guidance document for evaluating intermittent exposures to lead for scenarios such as recreational users and trespassers.

- Since the exposure frequency is less than three months, predicted intake values were compared with the provisional values discussed in Section 3.3.2.3.
- Table 3-5 and Table B-11 in Appendix B present the results of the lead intake calculations and lead screening. Only the ingestion pathway is quantified.

Table 3-5
Lead Intake Screening

EPC (mg/kg)		Intake (kg/day)		Predicted Intake (µg/day)		USEPA Provisional Intake Value (µg/day)	USEPA Provisional Intake Value (µg/day)
CTE	**RME**	**CTE**	**RME**	**CTE**	**RME**	**Men**	**Children <6**
Soil							
375.81	661.62	6.7E-07	2.7E-06	0.25	1.786	75	6
Sediment							
24.24	39.3502	2.6E-07	2.1E-06	.006	0.083	75	6
		TOTAL INTAKE		0.256	1.869	**75**	**6**

- Summary of Soil and Wasterock Lead Risks
  - The predicted intake was calculated to be 0.25 µg/day (CTE) and 1.786 µg/day (RME).
  - The USEPA provisional ingestion intake value for men (most likely receptor) is 75 µg/day and children under six (least likely receptor) is 6 µg/day.
  - If you assume that the total intake from dermal exposure and inhalation is equal to the intake from ingestion, no risk is expected for exposure to lead in soil and wasterock.
- Summary of Sediment Lead Risks
  - The predicted intake was calculated to be 0.006 µg/day (CTE) and 0.083 µg/day (RME).
  - Using the USEPA provisional ingestion intake listed above, no risk is expected for exposure to lead in sediment for the most likely recreational receptor (men), but a risk is possible for exposure to children under six using the RME EPC.
  - Given the steep terrain and remote nature of the Site, children less than six are not expected to spend extended periods of time at the Site; therefore, a risk is not expected from exposure to lead impacted sediment.
- Summary of Surface Water Lead Risks
  - The USEPA maximum containment level (MCL) for lead is 15 µg/L.
  - The maximum concentration of lead in surface water was 0.0023 mg/L; therefore, exposure to lead in drinking water is not expected to be a risk.

3.5 CALCULATION OF CLEANUP GOALS

- Site-specific cleanup goals protective of the RME recreational users were calculated for soil/wasterock and sediment based on the regulatory standard of 1×10^{-6} ECR.
- The Site-specific cleanup goals were calculated to be 143 mg/kg total arsenic for soil/wasterock.
- These clean-up goals are used to calculate hot spot concentrations in soil/wasterock.

3.6 DETERMINATION OF POTENTIAL HOT SPOTS

- The 1995 amendments to Oregon Revised Statute [ORS 465.315] and 1997 amendments to the Hazardous Substance Remedial Action Rules [OAR 340-122], commonly referred to as the Environmental Cleanup Rules, require that certain actions be taken for "hot spots" of contamination. These actions are:

- The identification of hot spots as part of the Remedial Investigation and Feasibility Study, and
    - The treatment of hot spots, to the extent feasible, as part of a remedial action selected or approved by the Director of ODEQ.
- The intent of the hot spot rule is to require treatment only for the worst contamination, as opposed to preferring treatment for all contamination at the Site.
- A hot spot in soil is generically defined as an area where the contamination is highly concentrated, highly mobile, or cannot be reliably contained. The assessment of "highly concentrated" hot spots is performed by comparing the concentration of each individual Site contaminant to its "highly concentrated" hot spot level as follows:
    - The "highly concentrated" hot spot levels correspond to a lifetime ECR of 1×10^{-4} for carcinogens and a hazard quotient of 10 for non-carcinogens.
    - The results of the hot spot evaluations are presented in Tables B-12 and B-13 in Appendix B. Using an ECR of 1×10^{-4}, a hot spot concentration for arsenic in soil/wasterock was calculated to be 14,330 mg/kg.
    - No hot spots were identified at the Site.

3.7 SUMMARY OF HUMAN HEALTH RISKS

- Current and future potential receptors were identified as hunters, hikers, and campers.
- Arsenic and lead were identified as the soil/wasterock, sediment, and surface water non-carcinogenic COPCs.
- No unacceptable non-carcinogenic health effects from arsenic or lead are anticipated under both the CTE and RME conditions.
- Arsenic was the only carcinogenic COPC identified at the Site.
- Carcinogenic risks were predicted from exposure to arsenic-impacted surface water and soil/wasterock under both the CTE and the RME exposure conditions.
- No carcinogenic risks were predicted from exposure to sediment.
- No hot spots were identified at the Site.

4.0 ECOLOGICAL RISK ASSESSMENT

- The goal of the ERA is to provide an understanding of the potential for ecological risks due to Site-related contamination and to allow a determination of whether remediation or more detailed ecological risk assessment are warranted. This ERA report consists of:
    - Description of the Site ecology and likely ecological receptors (including rare, threatened or endangered [RTE] species) at or near the Site;
    - Presentation of the conceptual ecological exposure model (CEEM), which provides a summary of potential and likely exposure media and pathways;
    - Delineation of assessment endpoints and measures;
    - Ecological risk-based screening; and
    - Risk characterization to assess the potential for ecological effects due to Site related COIs.
- An ecological survey was conducted as part of the SI (EA, 2004), which documented ecological features and conditions at and near the Site.
- The potential for Site-related ecological impacts were also assessed via an examination of stream benthic macroinvertebrate abundance and diversity.
- The ecological information collected during the SI has been incorporated into this risk assessment as appropriate.
- An ODEQ ecological scoping checklist was completed for this ERA, based on the SI ecological survey, and is provided in Appendix C.

4.1 PROBLEM FORMULATION

- Problem formulation was completed as follows:
  - The physical and chemical characteristics of the Site and the important ecological habitats, plants, invertebrates, fish, and wildlife that exist are described.
  - This information is utilized to identify the COIs, the ecological receptors of concern, exposure pathways, and the exposure media.
  - This, in turn, allows development of the CEEM, which graphically depicts the expected fate and transport of chemicals at the Site, the potential exposure media, and likely exposure pathways for ecological receptor types of concern.
  - The problem formulation concludes with identification of the ecological endpoints that delineate the objectives of the remainder of the ERA.
  - Generally, problem formulation includes a description of the Site and summary of previous investigations; however, this information is provided in the SI, and is not repeated herein.

4.1.1 Ecological Stressors

- Ecological receptors may be affected through exposure to chemicals (i.e., toxicity), physical stresses (i.e., destruction of habitat), and biological stresses (i.e., viruses and bacteria).
- Biological stressors were assessed as follows:
  - While biological stressors may affect ecological receptors, they are more frequently associated with waste food or human waste and in areas where wildlife congregate in large numbers.
  - Because the remote nature of the Site limits human presence and wastes, they are not considered to pose a threat to ecological receptors.
  - Because of the lack of suitable habitat, ecological receptors are also unlikely to congregate in the vicinity of the Site in numbers that could result in significant biological infection or passage of wildlife diseases.
  - Thus, biological stressors are unlikely to be a significant factor and are not considered further.
- Physical stressors were assessed as follows:
  - Past physical disturbances include development and operation of the mines and supporting structures, and possibly historic as well as current logging operations.
  - Because the Site has been abandoned for decades, current physical disturbance is reduced to a relatively low number of recreational users that visit or drive by the Site.
  - Given the relatively remote nature of the Site within the Wallowa Whitman National Forest, the ecological impacts of ongoing current physical disturbances are limited.

4.1.2 Ecological Setting

- The regional and Site-specific ecology are briefly described in this section to provide an understanding of the climate, plants, invertebrates, wildlife, and fish that may inhabit the Site and surrounding region:
  - Other than RTE species that must be considered on an individual level, a particular species must be potentially present on or utilize the Site in numbers adequate to allow an exposure level that may result in effects to the species' population. Such significant exposure to Site related COIs will only occur for those species known or expected to use the Site in high numbers on a regular basis or that bioaccumulate metals to a significant degree.
  - More detailed information on the regional and Site ecology, sensitive environments, and RTE species is presented in the SI.

- Bull trout and the mid-Columbia steelhead were the only threatened or endangered (i.e., protected) species observed or expected at or in the vicinity of the Site (EA, 2004).
  - Bull trout were identified in Granite Creek.
  - Steelhead are expected primarily downstream of the Site.
- Four distinct habitat types were observed at the Site by EA. These include; drier south facing slopes, moister north facing slopes, riparian zones along Granite Creek, and spruce forest at Monumental Mine.
- A lack of understory ground species was noted during SI activities; and logging, fire, and insect infestations have likely occurred in areas surrounding the Site. Wasterock piles typically included early-successional coniferous species.
- Overall, the relatively large number of species identified during this limited ecological survey suggested that numerous species are present in the vicinity of the Site and that they utilize varied habitat and foraging methods.
- Granite Creek flows throughout the Site and is generally less than one meter wide, with a riparian area less than 20 meters wide. EA described the riparian vegetation as being dominated by red alder (EA, 2004), although it is more likely mountain alder that was observed.

4.1.3 Conceptual Ecological Exposure Model

- The CEEM (Figure 4-1) graphically depicts the sources of contamination, contaminant release and transport mechanisms, impacted exposure media, and exposure routes for ecological receptor types observed or expected at the Site.
- Based on current understanding of Site conditions, the potentially contaminated exposure media for ecological receptors include:
  - Surface soil/wasterock in the vicinity of the Site;
  - Vegetation at the Site;
  - Surface water in Granite Creek, adit and wasterock seep drainages;
  - Pore water within Granite Creek; and
  - Sediment in Granite Creek.
- Given these exposure media, the possible and likely ecological receptor groups include:
  - Terrestrial plants exposed to COIs in soil/wasterock;
  - Terrestrial invertebrates exposed to COIs in soil/wasterock;
  - Terrestrial and semi-aquatic wildlife (including birds, mammals, and reptiles) exposed to COIs in soil/wasterock, surface/adit water, pore water, and sediment;
  - Aquatic life (including aquatic plants, aquatic invertebrates, fish, and amphibians) exposed to COIs in surface/adit water, and pore water; and
  - Benthic invertebrates, birds, and mammals exposed to COIs in sediment.

4.1.4 Assessment Endpoints and Measures

4.1.4.1 Assessment Endpoints

- Assessment endpoints represent the ecological aspects to be protected at a site and link the ERA to risk management decisions.
- Within a screening level ERA, assessment endpoints are generalized to reflect the risk-based screening process and protective ecological risk-based screening concentrations (ERBSCs). The assessment endpoints for this ERA include:
  - Protection of the reproduction and survival of plants, terrestrial invertebrates, birds, mammals, and reptiles exposed to COIs in surface soil/wasterock and vegetation at the Site;

- Protection of the reproduction and survival of aquatic life exposed to COIs in water within the adit/seep drainages and Granite Creek;
- Protection of the reproduction and survival of birds and mammals that may drink water from adit/seep drainages and Granite creek;
- Protection of the reproduction and survival of aquatic life exposed to COIs in pore water within Granite Creek;
- Protection of the reproduction and survival of benthic macroinvertebrates exposed to COIs in sediment within Granite Creek; and
- Protection of the reproduction and survival of birds and mammals exposed via the aquatic/benthic food chain to COIs in sediment within Granite Creek.

4.1.4.2 Assessment Measures

- Assessment measures are characteristics of the Site, selected ecological receptors, or ecosystem aspects that are measured through monitoring or sampling activities. Assessment measurements are then related, qualitatively or quantitatively, to the selected assessment endpoint(s) in order to determine whether an ecological effect is occurring. For this ERA, the assessment measures are comprised of the following:
  - Measured concentrations in soil/wasterock, surface water, pore water, and sediment; and
  - Readily-available ERBSCs.

4.2 ECOLOGICAL RISK-BASED SCREENING

- Ecological risk-based screening begins with a list of COIs in the media of concern, a determination of EPCs, and a comparison of the EPCs to ERBSCs with consideration of exposure to multiple chemicals and media, reporting limit adequacy, and the inordinate contribution of individual chemicals to the overall receptor group risk.
- The result is a list of Site-related chemicals of potential ecological concern (COPECs) with the potential to pose risks to ecological receptors at the Site.
- The initial screening was completed in Section 2.0 and the chemicals retained as ecological COIs were presented in Table 2-1.
- The ERBSCs used in the risk-based screening were screening level values (SLVs) provided by ODEQ (ODEQ, 2001).
  - When an SLV was not available for a given COI, an alternative ERBSC was selected from peer-reviewed literature or a surrogate chemical ERBSC was substituted.
  - The ERBSCs are presented in Table D-1.
- As per ODEQ guidance (2001), the EPCs for each medium were compared to the ERBSCs for each chemical and receptor group in each medium, resulting in chemical/receptor group-specific risk ratios (R_{ij} in Tables D-2 through D-5). Assessment of risk ratios was as follows:
  - Risk ratios were summed for all chemicals within a receptor group to obtain receptor group-specific risk ratios (R_j in Tables D-2 through D-5).
  - The potential for bioaccumulation of each COI was assessed, reporting limit adequacy was checked for undetected COIs, and the inordinate contribution of any given chemical to the overall receptor group risk was determined.
  - Risk ratios greater than 1 were considered unacceptable and indicative of potential risks for protected ecological receptors (bull trout and steelhead), aquatic life, and benthic macroinvertebrates.
  - Risk ratios greater than 5 were considered unacceptable for other ecological receptors.
  - The COIs for which potential ecological risks were indicated became COPECs for the Site.

- No ERBSCs are available for vegetation; therefore, a risk-based screening was not conducted for plant species. The potential for COPECs in vegetation to result in ecological risks is discussed further in the risk characterization section below.
- The risk ratios for receptor groups exposed to COPECs are shown in Tables 4-1 through 4-4.

Table 4-1
Chemicals of Potential Ecological Concern and Risk Ratios For Surface Soil/Wasterock

COPEC	Terrestrial Plants (R_{ij})	N*	Terrestrial Invertebrates (R_{ij})	n*	Birds (R_{ij})	N*	Mammals (R_{ij})	n*
Antimony	**17**	3	1	2	No ERBSC	0	**6**	2
Total Arsenic	**161**	13	**48**	6	**67**	13	**63**	9
Cadmium	2	1	0.4	0	1	0	0.06	0
Iron	**2,204**	2	**110**	2	No ERBSC	0	No ERBSC	0
Lead	**10**	5	1	0	**35**	6	0.1	0
Manganese	1	0	**6**	2	0.2	0	0.06	0
Mercury	**500**	3	**1,414**	3	**94**	2	2	1
Selenium	0.9	0	0.01	0	0.5	0	0.4	0
Silver	**100**	4	5	1	No ERBSC	0	No ERBSC	0
Vanadium	**22**	5	No ERBSC	0	1	0	2	0
Zinc	**13**	7	3	1	**11**	5	0.03	0
Total Receptor Group Risk (R_j)	**3,020**		**1,593**		**213**		**75**	

Bold = COPEC with risk ratio greater than acceptable levels; (>1 for protected species - none are expected; >5 for unprotected species)
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.
* n = number of stations with an unacceptable risk ratio.

Table 4-2
Chemicals of Potential Ecological Concern and Risk Ratios For Surface Water

Chemical of Potential Ecological Concern	Aquatic Life (R_{ij})	N*	Birds (R_{ij})	n*	Mammals (R_{ij})	n*
Arsenic, Total	0.2	0	0.001	0	0.004	0
Barium	**15**	13	0.0004	0	0.002	0
Iron	0.04	0	No ERBSC		No ERBSC	
Lead	0.5	0	0.00005	0	0.000004	0
Mercury	0.1	0	0.00003	0	0.000009	0
Selenium	0.3	0	0.0004	0	0.001	0
Total Receptor Group Risk (R_j)	**17**		0.002		0.01	

Bold = COPEC with risk ratio greater than acceptable levels (>1 for aquatic life; >5 for other species).
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.
* n = number of stations with an unacceptable risk ratio.

Table 4-3
Chemicals of Potential Ecological Concern and Risk Ratios for Pore Water

Chemical of Potential Ecological Concern	Aquatic Life (R_{ij})	n*
Arsenic, Total	0.05	0
Barium	**12**	11
Iron	0.02	0
Lead	0.6	0
Mercury	0.09	0
Selenium	0.4	0
Silver	Reporting Limit Too High	11
Thallium	0.07	0
Total Receptor Group Risk (R_j)	**14**	

Bold = COPEC with risk ratio greater than acceptable levels (>1 for aquatic life; >5 for other species).
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.
* n = number of stations with an unacceptable risk ratio.

Table 4-4
Chemicals of Potential Ecological Concern in Sediment

Chemical of Potential Ecological Concern	Benthic Macroinvertebrates (R_{ij})	n*	Birds and Mammals (R_{ij})	N*
Aluminum	No ERBSC		No ERBSC	
Arsenic, Total	**15**	20	**22**	10
Barium	No ERBSC		No ERBSC	
Beryllium	No ERBSC		0.003	0
Cadmium	1	4	**226**	20
Cobalt	No ERBSC		No ERBSC	
Iron	No ERBSC		No ERBSC	
Mercury	0.5	1	No ERBSC	
Selenium	No ERBSC	0	**6**	8
Thallium	No ERBSC		1	
Vanadium	No ERBSC		No ERBSC	
Zinc	0.7	1	**30**	20
Total Receptor Group Risk (R_j)	**21**		**287**	

Bold = COPEC with risk ratio greater than acceptable levels (>1 for benthic invertebrates; >5 for other species).
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.
* n = number of stations with an unacceptable risk ratio.

4.3 ECOLOGICAL RISK CHARACTERIZATION

4.3.1 Risk Description

- Risk description involves examining the predicted risks in each medium to determine whether they are likely, or artifacts of the risk assessment process.

4.3.1.1 Surface Soil/Wasterock

- The COPECs for soil/wasterock were listed in Table 4-1.
- COPECs are summarized below:
  - Cadmium and selenium were selected as COPECs due to the potential to bioaccumulate.
    - The synthetic precipitation leaching procedure (SPLP) results for these two COPECs (EA, 2004) suggest that they are strongly bound to soil/wasterock particles, and thus, are not readily bioavailable.
    - As such, it is unlikely they will bioaccumulate to any significant degree in birds or mammals.
    - Based on this and the lack of an exceedance of ERBSCs by the EPC, cadmium and selenium are not considered to present a significant risk to ecological receptors.
  - Arsenic, iron, and mercury risk ratios were inordinately high for at least one receptor group.
    - Iron and mercury only exceeded ERBSCs at two and three sample locations, respectively; all but one of these exceedances were in three samples collected at the Monumental Mine.
    - Iron concentrations exceeded the associated background concentrations by a maximum factor of only 1.3.
    - For mercury, the highest exceedences of ERBSCs occurred in plants and invertebrates.
    - The only other exceedences observed with regard to mercury occurred at the Monumental Mine in three sample locations for birds and one sample location for mammals.
    - Overall, predicted risks for total arsenic are spread across receptor groups and sampling locations, whereas predicted risks for mercury and iron are limited primarily to plants and invertebrates at the Monumental Mine.
  - The five COPECs with unacceptable risk ratios at more than three sample locations included total arsenic, lead, silver, vanadium and zinc.
    - Silver had five unacceptable risk ratios (four plant and one invertebrate) at the Monumental Mine.
    - Zinc had 13 unacceptable risk ratios (7 for plants, 1 for invertebrates, and five for birds), primarily at the Monumental and Tillicum Mines.
    - Lead had 11 unacceptable risk ratios (5 for plants and 6 for birds) in samples collected at 4 of the mines.
    - Vanadium had five unacceptable risk ratios for plants spread across all the mines.
    - Total arsenic had multiple unacceptable risk ratios for multiple receptors at all the mines; the majority of these ratios were observed at the Monumental and Tillicum Mines.
- Based on the number and locations of samples where the unacceptable exceedances of ERBSCs and background concentrations occurred, the results of the risk-based screening suggest that:
  - Total arsenic poses potential risks to multiple receptor groups at the Monumental and Tillicum Mines.
  - Mercury, silver, and zinc may pose risks, primarily at the Monumental Mine.
  - Zinc may also pose unacceptable risks to plants at the Tillicum Mine.

4.3.1.2 Vegetation

- Vegetation samples were collected from four background and six locations likely to be impacted by Site-related COPECs.
- The COPECs present in vegetation above background concentrations included total arsenic, beryllium, cadmium, total chromium, copper, iron, lead, mercury, vanadium, and zinc (See Table A-4 in Appendix A).
- The maximum ratios of onsite concentrations to background concentrations were total arsenic, (10), beryllium (1), cadmium (7), total chromium (5), copper (1), iron (2), lead (2), mercury (2), vanadium (1), and zinc (3).
- Beryllium, copper, iron, lead, mercury, and vanadium are present at less than or approximately equivalent to two times the background concentration and, thus, are not considered to present a significant potential for ecological impacts.
- Zinc is an essential nutrient in the environment that is only moderately elevated in vegetation compared to its background concentrations. This diminishes the predicted potential for impacts due to zinc.
- Total arsenic and cadmium significantly exceeded background concentrations at the Monumental Mine, while total chromium significantly exceeded background concentrations at the Central Mine.
- Overall, total arsenic, cadmium, and total chromium are the COPECs of greatest concern in vegetation.
- Limited amounts of vegetation are located on or near the wasterock piles at the Site; therefore, the potential exposure of herbivores to Site-related contamination is significantly reduced.

4.3.1.3 Surface Water

- The COPECs for surface water are listed in Table 4-2. No background surface water samples were collected during the SI.
- Barium was the only constituent to exceed applicable ERBSCs.
    - The differences between the highest and lowest detected concentrations was less than a factor of three, and less than or equivalent to a factor of two, with the exception of sample SP-SFW-19 at the Monumental Mine.
    - Therefore, barium is not considered to be significantly elevated.
- Iron was selected as a COPEC based on the lack of ERBSCs.
    - Iron was only detected in two samples at very low concentrations, and the difference between the highest and lowest detected concentration was less than a factor of three.
    - Iron is therefore not considered to be significantly elevated at the Site.
- Total arsenic, lead, mercury, and selenium concentrations did not exceed ERBSCs, but were selected as COPECs based on bioaccumulation potential.
    - Total arsenic was detected in four samples; lead was detected in three samples; mercury in two samples; and selenium in one sample.
    - These detections occurred primarily in the farthest upstream and/or the farthest downstream samples. The limited number of detections suggests that these COPECs are not widespread and thus, are not likely to bioaccumulate significantly.
    - However, the presence of these metals at the Monumental Mine and the reappearance downstream from the Central Mine, suggests a potential for these mines to be sources of COPECs to Granite Creek.
- Overall, slightly elevated concentrations of a few COPECs were noted at the upstream and downstream surface water stations.

4.3.1.4 Pore Water

- The COPECs for pore water were listed above in Table 4-3. No background pore water samples were collected during the SI.
- Barium was the only detected COPEC that exceeded an ERBSC.
  - The difference between the lowest and highest detected concentrations was less than a factor of 2; therefore, barium is not considered to be significantly elevated at the Site.
- Thallium was selected as a COPEC due to a lack of ERBSCs.
  - Thallium was detected in one sample at very low concentrations and the difference between the highest detection and lowest detection limit was less than a factor of 3.
  - Thallium is not considered to be significantly elevated at the Site.
- Total arsenic, lead, mercury, and selenium concentrations did not exceed ERBSCs, but were selected as COPECs based on bioaccumulation potential.
  - As with surface water, the presence of these metals in only a few sample locations at very low concentrations strongly suggests the presence is not likely to result in population level ecological impacts.
  - However, it should be noted the highest detected total arsenic concentrations occurred in samples collected from the two farthest downstream stations on Granite Creek.
- Silver was not detected in pore water at the Site, but one-half the detection limit exceeds the ERBSC by a maximum factor of 12.
  - Because silver was not detected in any surface water or pore water samples and the detection limits are relatively low (2.9 micrograms per liter [μ/L]), it is considered unlikely silver contributes to ecological risks at the Site.

4.3.1.5 Sediment

- The COPECs for sediment were listed above in Table 4-4. No background sediment samples were collected during the SI.
- Total arsenic, cadmium, selenium, and zinc were the only COPECs with unacceptable risk ratios.
  - The predicted risks for total arsenic, cadmium, and zinc were spread widely across the Site.
  - The highest risk ratios occurred in samples collected from the four stations located farthest downstream.
  - Selenium risk ratios were all less than 10 in 8 of the 20 sample locations and were spread intermittently across the Site.
- Aluminum, barium, beryllium, cobalt, iron, thallium, and vanadium were selected based on a lack of ERBSCs.
  - Since no background samples were collected, the difference between the highest and lowest detection limit was examined for these COPECs.
  - The difference for aluminum, barium, beryllium, cobalt, and iron were less than a factor of 10; thallium and vanadium had differences that were factors of 14 and 12, respectively.
  - Three stations (PSD-03, RSD-06, RSD-10) contained the highest concentrations of iron, thallium, and vanadium, whereas samples collected from the remainder of the stations contained comparable COPEC concentrations.
- Mercury was selected as a COPEC due to the lack of a bird/mammal ERBSC and the potential for bioaccumulation; the maximum mercury detection is approximately 12 times higher than the lowest detection at station PSD-54.
- Overall, total arsenic, cadmium, and zinc were detected at multiple locations along the entire length of Granite Creek at the Site and have the potential to cause ecological impacts.
- Potential impacts due to mercury and selenium are less likely, but the distribution of these COPECs may suggest they are Site-related.

4.3.2 Ecological Hot spots

- Ecological hot spots are defined as concentrations that are 10 times greater than the ERBSCs.
- Antimony, total arsenic, copper, lead, mercury, silver, and zinc hot spots were identified in multiple wasterock samples.
- Barium hot spots were identified in several surface water and pore water samples.
- Total arsenic, cadmium, and zinc hot spots were identified in several sediment samples.
- No background samples were collected for surface water, pore water, or sediment; therefore:
  - o The ecological hot spot analysis for these media is based solely upon exceedance of the ERBSC by a factor of 10 or more.

Table 4-5
Locations of Ecological Hot Spots

Soil	Surface Water	Pore Water	Sediment
MM-ML-SSS-16			
MM-ML-SSS-38	MM-SP-SFW-18	TM-ST-PWP-07	CMM-ST-PSD-03
MM-WP-SSS-13	MM-SP-SFW-19	TM-ST-PWP-08	CMM-ST-RSD-03
MM-WP-SSS-14	MM-SP-SFW-51	CM-ST-PWP-09	CMM-ST-RSD-04
MM-WP-SSS-15	CMM-ST-SFW-04	CM-ST-PWP-10	SM-ST-PSD-05
MM-WP-SSS-17	SM-ST-SFW-06	CM-ST-PWR-10	SM-ST-PSD-06
CMM-WP-SUS-21	TM-ST-SFW-07	GC-ST-PWP-53	SM-ST-RSD-05
TM-WP-SSS-28	TM-ST-SFW-08	GC-ST-PWP-54	SM-ST-RSD-06
TM-WP-SUS-26	CM-ST-SFW-09		TM-ST-PSD-07
TM-WP-SSS-27	CM-ST-SFW-10		TM-ST-PSD-08
CM-WP-SSS-31	GC-ST-SFW-53		TM-ST-RSD-07
	GC-ST-SFW-54		TM-ST-RSD-08
			CM-ST-PSD-09

4.3.3 Uncertainty Analysis

- The uncertainty analysis lists the common uncertainties associated with ecological risk-based screening and assesses whether they are likely to over- or underestimate the potential for ecological risks to be realized at the Site.
- The primary uncertainties associated with this ecological risk-based screening and the impacts on the prediction of the potential for ecological risks are discussed below:
  - o The risk-based screening assumes the receptors are constantly exposed to the chemical at a concentration equal to the EPC.
    - ▪ This may be true for immobile species such as plants and some terrestrial invertebrates; however, unless the contamination is widely and evenly spread, it is not realistic for wildlife species.
    - ▪ Because the metals are primarily located around wasterock piles and small centers of mining activity, the risks calculated above overestimate the actual risks posed to wildlife.
  - o The use of maximum detected concentration or 90UCL as the EPC is a conservative approach that is purposefully designed to result in some overestimation of the potential for ecological risks. Because of this, the risks predicted are likely to overestimate actual ecological risks.
  - o Including a sample's laboratory reporting limit screening is a conservative approach that includes COIs as COPECs when not actually detected. Because the undetected COI is likely present at concentrations less than the reporting limit, possibly much less, including the COI as a COPEC results in an overestimation of the potential for ecological risks.

- The lack of site-specific bioavailability data does not allow for a formal assessment of risks due to some COPECs for upper trophic level receptors (i.e., birds and mammals).
  - However, the fact that many metals bind strongly to soil and sediment particles suggests that many of the metals may not be readily bioavailable.
  - Given this, risks due to the bioaccumulation of COPECs are likely overestimated.
- Except for benthic macroinvertebrates and aquatic life, the ERBSCs used for this ERA are intended to be no-observed-adverse-effect-levels (NOAELs).
  - Because actual ecological effects occur at an unknown concentration somewhere between the NOAEL and the LOAEL, simply exceeding an ERBSC does not necessarily indicate the potential for significant ecological effects.
  - Thus, the use of NOAEL-based ERBSCs likely results in an overestimation of the potential for ecological risk.
- The lack of ERBSCs for some receptors precludes the calculation of risk for those receptors, which may result in an over- or underestimation of the potential for ecological risks. The use of a bioaccumulation screening is a conservative measure used to assess the potential for risks posed to upper trophic level ecological receptors when appropriate ERBSCS are missing.
- Within this ERA, predictions are made regarding the significance of ecological exposures under current conditions at the Site. Overall, the risk-based screening is designed to overestimate the potential for ecological risks.

4.4 SUMMARY OF ECOLOGICAL RISKS

- Predicted ecological risks due to total arsenic are widespread in wasterock at all five mines, with the Monumental and Tillicum Mines exhibiting the highest predicted risk.
  - To a lesser extent, antimony, iron, lead, mercury, silver, vanadium, and zinc also contribute to the predicted risks.
  - Immobile receptors, such as plants and invertebrates, are likely impacted by wasterock.
  - Individual birds and small mammals are also likely to be impacted by wasterock; however, population level impacts are not expected to the more mobile terrestrial species.
  - The majority of ecological hot spots were associated with total arsenic in wasterock at the Monumental and Tillicum Mines; ecological hot spots were also identified for antimony, total arsenic, lead, mercury, and silver, and were spread across the Monumental, Tillicum, and Central Mines.
- Cadmium and total chromium in vegetation at the Site were detected at concentrations greater than five times the background vegetation concentration; total arsenic was elevated more than 10 times higher than background indicating that vegetation at the Site may be impacted.
- Barium was the only COPEC in surface water and pore water that exhibited ecological risk.
  - These risks and some of the other COPECs likely would not have been identified if background samples would have been collected from Granite Creek.
  - Not including barium, all other COPECs were selected based on bioaccumulation potential or a lack of ERBSCs.
  - While barium and silver hot spots were noted in surface water and pore water, it is likely related to the lack of background concentration data for barium and the elevated detection limits for silver.
  - The highest concentrations of several COPECs in surface water and pore water were observed in samples collected at the farthest upstream and downstream sample locations, which suggests the Monumental Mine and Central Mine may be a source of COPECs to Granite Creek.

- Elevated risk ratios for total arsenic, cadmium, selenium, and zinc were identified in sediment.
    - Total arsenic, cadmium, and zinc appear likely to have the highest potential to impact immobile receptors or those that are frequently exposed to COPECs in sediment.
    - Hot spots for several metals were noted at nearly all the sediment sampling locations.
    - The lack of background samples may have resulted in the inclusion some of the COPECs with elevated risk ratios and hot spots, when in fact they may be present below background concentrations.

5.0 CONCLUSIONS

- The following conclusions were developed from the HHRA:
    - Current and future potential receptors were identified as hunters, hikers, and campers.
    - Arsenic and lead were identified as the soil/wasterock, sediment, and surface water non-carcinogenic COPCs.
    - No unacceptable non-carcinogenic health effects are anticipated under both the CTE and RME conditions.
    - Arsenic was the only carcinogenic COPC identified at the Site.
    - Carcinogenic risks were predicted from exposure to arsenic-impacted surface water and soil/wasterock under both the CTE and the RME exposure conditions.
    - No carcinogenic risks were predicted from exposure to sediment.
    - No hot spots were identified at the Site.
- The following conclusions were developed from the ERA:
    - Ecological impacts were predicted for immobile species, primarily terrestrial plants and terrestrial invertebrates, due to COPECs in soil and wasterock. Local and regional populations of these and other terrestrial species are unlikely to be significantly impacted.
    - Ecological impacts were also predicted for aquatic life and wildlife exposed to COPECs in surface water and pore water. However, the lack of background COPEC concentrations for these media made it more difficult to predict the potential for impacts.
    - Benthic invertebrates and wildlife appear to have the potential to be impacted by total arsenic, cadmium, and zinc, which are present at elevated concentrations, at nearly all sediment sample locations. The lack of background COPEC concentrations in sediment likely results in an overestimation of these potential impacts.
    - The Monumental and Tillicum Mines appear to have more locations with elevated COPEC concentrations in wasterock than the other mines.

6.0 RECOMMENDATIONS

- Based on the information presented in this report, CES recommends the following:
    - Performing an Engineering Evaluation / Cost Analysis (EECA) at the Site because:
        - Unacceptable carcinogenic risks were predicted from exposure to arsenic in wasterock under the CTE and RME recreational exposure scenarios.
        - Ecological risks were predicted from exposure to multiple COPECs in all media.
        - Multiple ecological hot spots were identified in all media.
    - As part of the EECA, a data gap investigation should be completed, a preliminary list of data gaps are listed below:
        - Collect additional background soil samples in order to accurately calculate the 90UCL for background concentrations.
        - Collect background surface water and sediment samples from Granite Creek.
        - Collect additional soil samples along the banks of Granite Creek to assess the impacts from the Site.

- Perform additional reconnaissance of each mine to verify Site conditions, locate additional workings, and collect additional soil, wasterock and tailings samples in order to delineate the extent of contamination.
- Perform a detailed topographic survey at each mine; this information will be used to accurately determine the volume of wasterock and material at the Site.
- Rerun the risk assessment calculations, including the additional samples collected, to further evaluate the human and ecological risks at the Site.

USFS 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 USDA Forest Service. 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, USDA Forest Service 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 Sites 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 Forest Service and EPA Headquarters before making a determination to include this site on the Federal Agency Hazardous Waste Compliance Docket.

Prepared by:

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Exp. 06/30/2006

7.0 REFERENCES

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian Soil Quality Guidelines. Canadian Council of Resource and Environmental Ministers. Winnipeg.

Dutch Ministry of Housing, Spatial Development and the Environment (DMHSPE). 2001. Technical Evaluation of the Intervention Values for Soil/Sediment and Groundwater, Human and Ecotoxicological Risk Assessment and Derivation of Risk Limits for Soil, Aquatic Sediment and Groundwater. Dutch Ministry of Housing Special Development Planning and the Environment, Beethoven, The Netherlands. RIVM Report 711701023. February.

EA. 2004. Site Inspection Report. Granite Creek Mines. Wallowa Whitman National Forest. January. EA, Engineering, Science, and Technology. Bellevue, Washington.

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. ES/ER/TM-126/R2. Prepared for the U.S. Department of Energy, Office of Environmental Management.

Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones. 1997b. Preliminary Remediation Goals for Ecological Endpoints. ES/ER/TM-162/R2. Prepared for the U.S. Department of Energy, Office of Environmental Management.

Hazardous Substances Databank (HSDB). 2001. National Library of Medicine On-line Database. http://toxnet.nlm.nih.gov/ .

Oregon Department of Environmental Quality (ODEQ). 1998. Guidance for Conduct of Deterministic Human Health Risk Assessment, Final. Waste Management and Cleanup Division Cleanup Policy and Program Development.

Oregon Department of Environmental Quality (ODEQ). 2001. Guidance for Ecological Risk Assessment. Waste Management and Cleanup Division, Oregon Department of Environmental Quality. December.

USEPA. 1991. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals). Interim. EPA Publication 9285.7-01B, Office of Emergency and Remedial Response. Washington, D.C.

USEPA. 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum, Washington, D.C., EPA /630/R-92/001.

USEPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. Environmental Response Team. Edison, New Jersey. June.

USEPA. 1998. Guidelines for Ecological Risk Assessment. Final. Risk Assessment Forum. EPA /630/R-95/002F. Washington DC. April.

USEPA. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Solid Waste and Emergency Response. EPA530-D-99-001C. Table E-1, Page E-13.

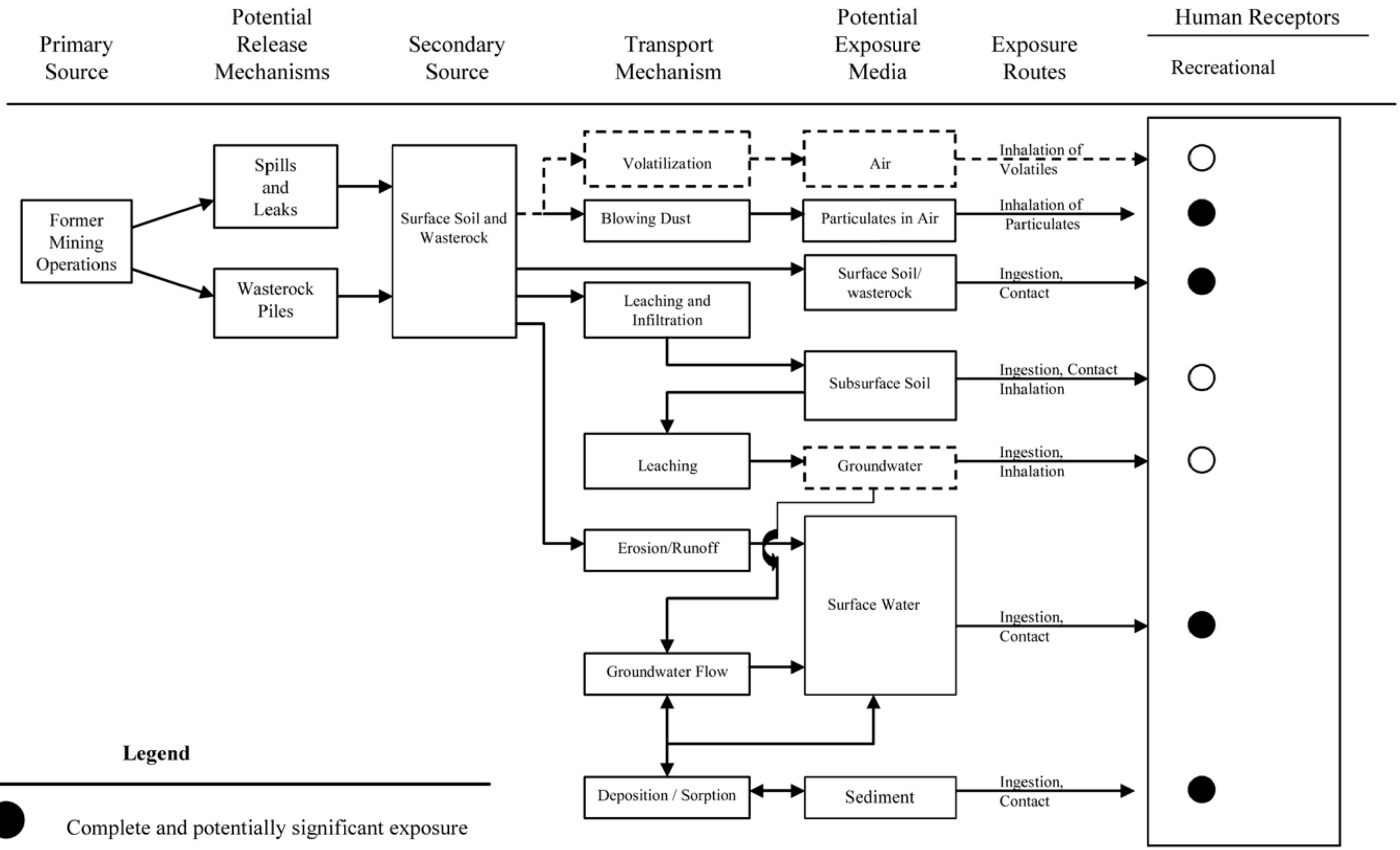
USEPA, 2002. List of Drinking Water Contaminants and MCLs, National Primary Drinking Water Regulations. EPA 816-F-02-013.

USEPA. 2003. Assessing Intermittent or Variable Exposure at Lead Sites. OSWER 9285.7-76.

USEPA. 2004. Region 9 Preliminary Remediation Goals (PRGs).

USEPA. 2004. Integrated Risk Information System (IRIS). http://www.epa.gov/iris/.

FIGURE 3-1: Conceptual Human Health Exposure Model



Legend

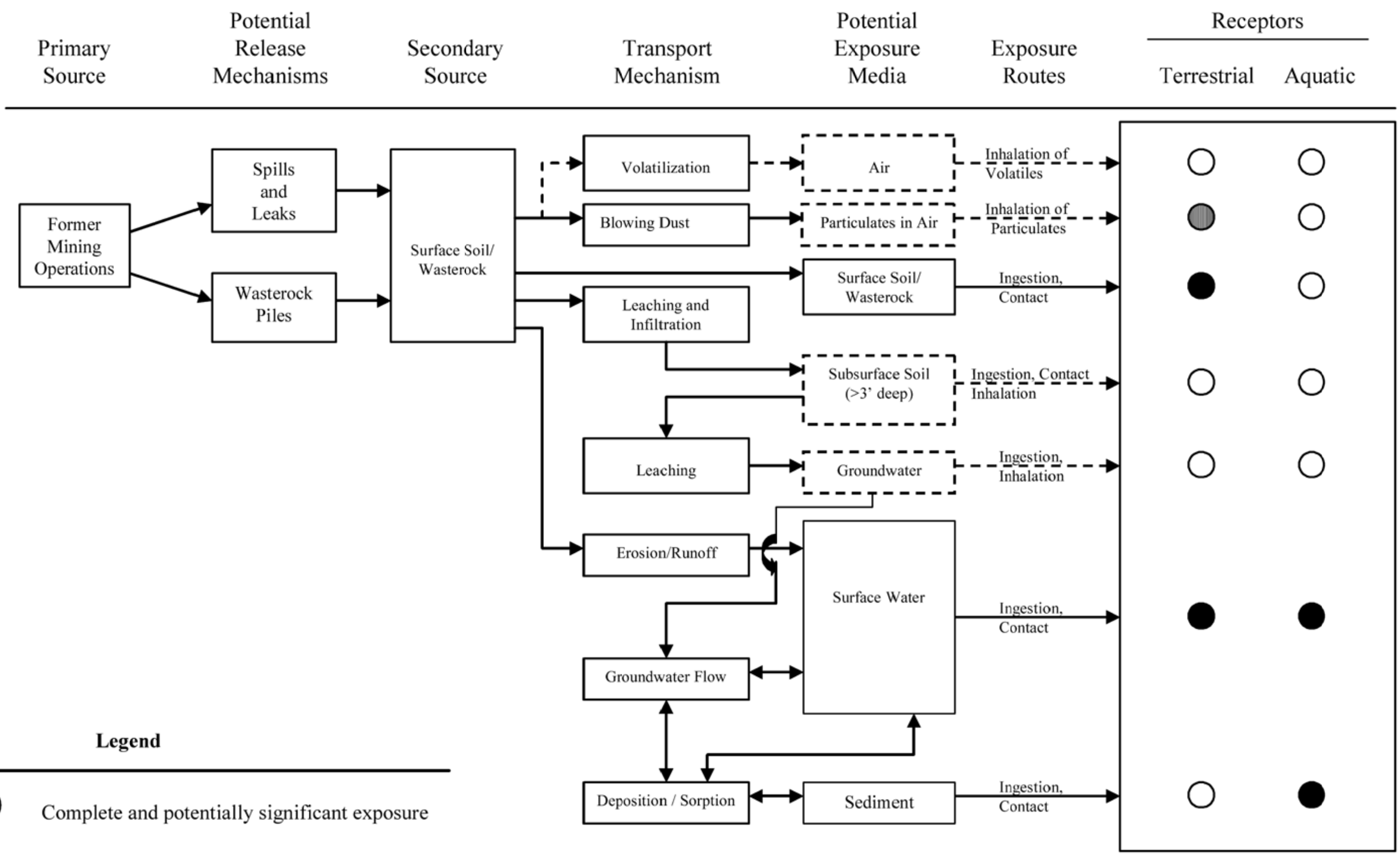
- ● Complete and potentially significant exposure
- ◐ Potentially Complete but insignificant exposure (not to be quantified)
- ○ Incomplete Exposure (not to be quantified)
- - - Insignificant or Incomplete Pathway or Medium
- — Complete and/or Significant Pathway or Medium

(SOURCE: TAS, 1/30/06)

Figure 3-1. Conceptual Human Exposure Model

PROJECT NUMBER: 2523046		RISK ASSESSMENT
DATE: 04/08/06		
DWG. DGW	DWG NO: 2523046F1.dwg	GRANITE CREEK MINES WALLOWA WHITMAN NATIONAL FOREST
PROJECT MANAGER: DGW		
REVISED:		CES CASCADE EARTH SCIENCES A Valmont Industries Company

FIGURE 4-1: Conceptual Ecological Exposure Model



Legend

- ● Complete and potentially significant exposure
- ◐ Potentially Complete but insignificant exposure (not to be quantified)
- ○ Incomplete Exposure (not to be quantified)
- - - Insignificant or Incomplete Pathway or Medium
- — Complete and/or Significant Pathway or Medium

(SOURCE: TAS, 1/30/06)

Figure 4-1. Conceptual Ecological Exposure Model

PROJECT NUMBER: 2523046	RISK ASSESSMENT
DATE: 04/08/06	
DWG. DGW / DWG NO: 2523046F2.dwg	GRANITE CREEK MINES WALLOWA WHITMAN NATIONAL FOREST
PROJECT MANAGER: DGW	
REVISED:	CES CASCADE EARTH SCIENCES A Valmont Industries Company