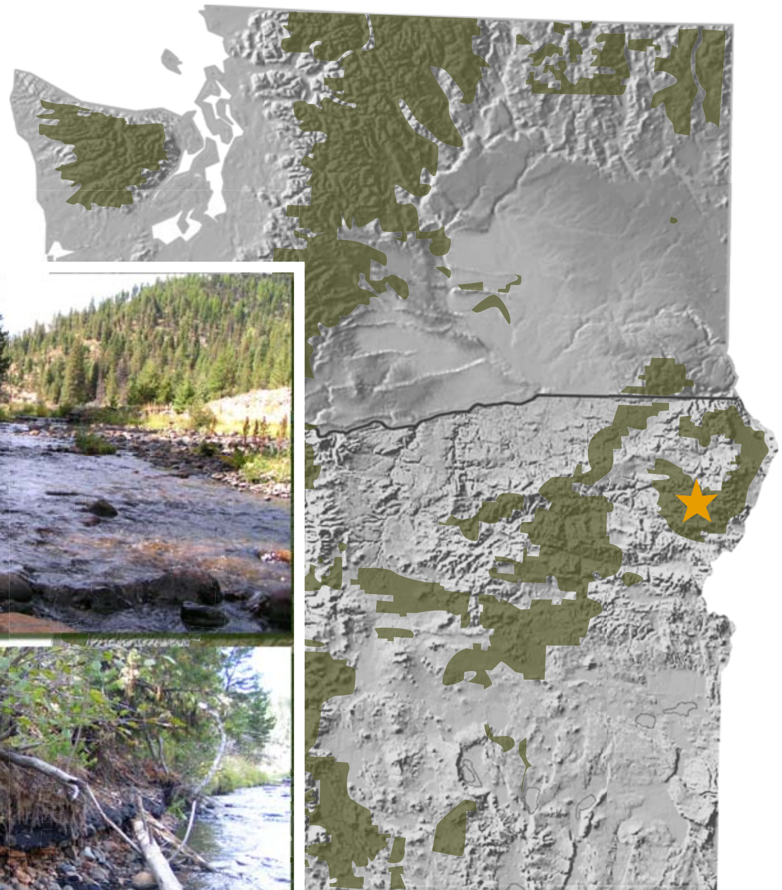
**FINAL**

# ENGINEERING EVALUATION/COST ANALYSIS
# BLUEBIRD MINE SITE
# GRANITE, OREGON



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## EXECUTIVE SUMMARY

Science Applications International Corporation (SAIC) has prepared the following Engineering Evaluation/Cost Analysis (EE/CA) for completing a non-time-critical removal action related to hazardous substances released to the environment from the abandoned Bluebird Mine Site located near the town of Granite in Grant County, Oregon. The site encompasses about 2 acres and consists of one adit. A recently installed pipeline drains mine water from the adit to a settling pond channel away from Clear Creek. There are remnants of a possible former mill site and an old settling pond area that historically received uncontrolled mine water discharge. Approximately 6,000 cubic yards of waste rock are scattered over the moderately-steep slopes; a large erosion gully and other areas of potential erosion have been observed.

This EE/CA is being prepared under the Comprehensive Environmental Response and Liability Act (CERCLA) cleanup authorities [42 USC 9604(a) and 7 CFR 2.60(m)] and associated regulations in 40 CFR 300.415(b). The purpose of this EE/CA is to select a preferred alternative that would minimize or eliminate the risk of a hazardous release from the mine that could adversely affect the environment and/or public health and welfare.

The objective of the removal action is to prevent or reduce the potential of mining-related materials to cause unacceptable levels of risk to humans and the environment, while meeting applicable or relevant and appropriate requirements (ARARs) to the extent practicable. Based on the results of the streamlined human health risk evaluation and ecological risk assessment, no adverse human health or terrestrial ecological risks from exposure to soils and waste rock are expected. Therefore, preliminary remediation goals for these sources were not developed. In accordance with 40 CFR 300.401(e)(2(f)(5) the EE/CA process is determined complete for the soils and waste rock areas, because the amount, quantity, or concentrations released do not warrant further response at this time.

With respect to protecting Clear Creek and threatened salmonids, the USFS has recently installed a new adit discharge system into settling ponds west of the County road. The current configuration of the ponds with a plugged culvert indicates no current adverse risk to the creek. However, adverse risks to Clear Creek could be likely if the culvert becomes unplugged. Numerous data gaps have been identified that need to be filled prior to developing serious alternatives for the settling pond should the culvert be unplugged. Consequently, a supplemental EE/CA or an addendum to this EE/CA should be prepared after the data gaps regarding the settling pond issue have been collected and analyzed.

# 1.0 INTRODUCTION

This report presents the results of an Engineering Evaluation/Cost Analysis (EE/CA) for the Bluebird Mine Site (Site) located in the Umatilla National Forest near Granite, Oregon. The report was prepared for the U.S. Department of Agriculture, U.S. Forest Service (USFS) Region 6 under Contract Number 53-05K3-4-0021, Task Order SAIC-4-001 pursuant to 42 USC 9604(a), 7 CFR 2.60(m), and Federal Executive Order 12580. The report complies with the provisions of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR 300.415(b) (4) (i), and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The purpose of this EE/CA is to select an alternative that would minimize or eliminate the risk of a release from the mine that could adversely affect the environment or public health and welfare as stipulated in 40 CFR 300.415(b)(2)(i)-(viii).

# 2.0 SITE CHARACTERIZATION

## 2.1 Site Description and Background

The following sections present information on site location and status, previous removal actions, physiography, climate, geology/soils, hydrogeology, hydrology, surrounding land use, and sensitive ecosystems. Additional descriptions of the Site are contained in the Site Inspection (SI) report (EA Engineering 2003).

### *2.1.1 Site Location and Status*

The abandoned Site is located off Grant County Road 24, approximately 3 miles southwest of the town of Granite, in Grant County, Oregon. The Site is adjacent to Clear Creek within the Granite Mining District (Figure 1) at latitude 44° 45’ 59” North, longitude 118° 29’ 37” West, in Section 11, Township 9 South, Range 35 East, Willamette Meridian.

The inactive site covers an area of approximately 2 acres on moderate to steep hillsides. A map showing existing site features is presented in Figure 1. The site consists of one adit located approximately 50 vertical feet above the elevation of Clear Creek. The mine’s first 20 feet had originally intercepted surficial soils before reaching solid rock. There is no ground support and the surface soils above the portal are unstable. This unsupported area currently reaches a height of up to 35 feet above the current portal and results in sloughing of soils and rock falls into the opening. This destabilized area presents a danger to personnel that might be working below it and will eventually result in collapse of the opening that could threaten future operations and maintenance of the mine water pipeline drain system. The USFS is currently developing a plan to stabilize the portal area and protect the integrity of the discharge pipeline described below.

From the adit, an 8-inch-diameter, high-density polyethylene (HDPE) pipe having fusion-welded joints was recently installed and runs directly westward from the portal, goes underneath Clear Creek, crosses the county road, and discharges to a pond on USFS lands directly west of the road. A culvert at the downstream end of the pond is currently plugged (reason unknown, although likely to be caused by vegetative material and sediment deposits), which causes pond water to seep through a berm on to adjacent private land to the north (see Figure 1). The flow rate on September 9, 2004 was measured at 83 gallons per minute.

An old settling pond was constructed about 200 feet north of the mine portal and appears to have been originally excavated out of native soils using a bulldozer. The pond, currently inactive, has approximate dimensions of 100 feet in length by 25 feet in width. The estimated designed depth is approximately 4 feet. The bottom has a general reddish yellow rust color from ferrous iron staining. This staining is from mine water previously discharged into the pond from the Site portal.

There are remnants of a wooden structure located adjacent to the old settling pond that include about 20 square feet of floor set on wooden sleepers and about 1 foot of the lower portion of the back wall in the southeast corner. The tops of the remaining portions of the walls are charcoaled, indicating that the structure had likely burned, and that the remaining portions were saved because they had been buried and thus protected from the fire. A small concrete foundation was observed that was likely used for mounting a small piece of machinery. No larger foundations were found. The USFS identified this building to be a possible former mill (Dennis Boles, Pers. Comm. 2004). Some tailings-like material were found lying on top of the remains of the building's wooden floor. This material has average approximate dimensions of 4.5 x 5 x 1 foot or 0.8 cubic yards (covering an area of approximately 18 sf).

A few waste rock piles occur on the site and are somewhat mixed together. These piles are divided into the north, west, and south piles, with a total estimated volume of approximately 6,000 cubic yards. A deep eroded cut exists between the mine portal and the area where the diversion ditch turns northward to the old settling pond. Eroded material has moved downhill to the west into the area referred to in this report as the west waste rock pile. Part of this pile has been pushed in with a bulldozer to divert mine water from the portal to the settling pond.

The area between the south edge of the cut and the north edge of the south waste rock pile has recently been disturbed by the installation of the drainage pipeline. The pipeline has an average slope that approaches 21 percent and this area. However, much of the waste rock is coarse material and appears to be not readily susceptible to erosion into Clear Creek.

Acid Mine Drainage (AMD) from the adit is of principal concern. The acidic water tends to mobilize heavy metals into solution. Metals in the waste piles are also of potential concern.

In 1996, the U.S. Environmental Protection Agency (USEPA) collected and analyzed surface water and sediment samples from the site and reported that several metals in each medium exceeded preliminary risk-based screening guidelines (USEPA 1997). In the summer of 2003, a site investigation was conducted and a Site Inspection (SI) report was completed in December 2003 (EA Engineering 2003). The data presented in the SI report and information collected from supplemental field sampling by SAIC in September 2004 form the basis of this EE/CA. Information from the SI regarding Site physiography, climate, geology, hydrogeology, and hydrology are not repeated here.

### *2.1.2 Previous Removal Actions*

Efforts by the USFS to prevent mine drainage from the adit to discharge directly into Clear Creek began in the 1960s. Major work began in the 1980s with the installation of a wooden bulkhead in the mine portal and a discharge pipe that diverted water south of the site and into a pond located on the west side of Clear Creek and Grant County Road 24, on private land. There is no file on the construction of this system (EA Engineering 2003). In the summer of 2004, a new 8-inch pipeline was installed to divert the mine water into a pond on lands administered by the USFS directly west of Clear Creek and the County road. Periodic drainpipe maintenance and cleaning currently occurs. The total volume of mine water being treated in the pond is unknown. These flows include surface runoff from roads and adjacent ground surfaces, springs and seeps both upgradient and likely within the area of the pond, and possibly from mine discharges from the Red Boy property (Boles, 2004) located to the south.

Monitoring efforts are underway by Cascade Earth Sciences to determine the potential changes in discharge rates and water quality being discharged from the mine.

#### *2.1.3 Surrounding Land Use*

The Site is on lands administered by the Umatilla National Forest. The nearest private lands occur west and adjacent to the Site. Mining is the predominant land use on private property in the watershed. Numerous claims are active, especially upstream of the Site and there are several private land parcels in the area. Recreation is common in the area, consisting of hunting, hiking, and camping at scattered locations. Hunting season typically begins in October and extends through November. General public fishing is not allowed in Clear Creek due to the salmon restoration program, with the exception of ceremonial native Tribal fishing. Forest Road 10 is used as a groomed snowmobile trail typically between December and March. The small town of Granite, approximately 4 road miles away from the Site, provides limited goods and services.

#### *2.1.4 Sensitive Ecosystems*

Clear Creek is a sensitive environment that functions as a migratory pathway and spawning area critical to the maintenance of anadromous fish species.

**Threatened, Endangered, and Sensitive Species.** Two federal-listed threatened species have been reported within the reach of Clear Creek found within the project area: bull trout (*Salvelinus confluents*) and steelhead (*Oncorhynchus mykiss*). These species are designated by the State of Oregon as sensitive-critical species (bulltrout) and sensitive-vulnerable species (steelhead).

The westslope cutthroat trout (*Oncorhynchus clarki lewisi*), reported within 2 miles of the site, is designated as a federal species of concern and a state-sensitive species. The interior redband trout (*Oncorhynchus mykiss gairdneri*), a state-sensitive species, is also common in Clear Creek. The Columbia spotted frog (*Rana luteiventris*), a state-sensitive species, has been observed in a side channel of Clear Creek.

**Wetlands and Wildlife Breeding Areas.** The portion of Clear Creek, found within the site vicinity, is characterized as *riverine, upper perennial, unconsolidated bottom, permanently flooded*. There are several small wetland ponds across from the Site on the west side of Grant County Road 24. These ponds currently receive the mine drainage water from both Red Boy and the Bluebird Mine Sites and have variable classifications on the National Wetlands Inventory. There are no known designated wildlife breeding areas located in the site vicinity.

### 2.2 Source, Nature, and Extent of Contamination

This section describes the nature and extent of environmental contamination at the Site. The primary source of information and data for the site is provided in the SI report (EA Engineering 2003). In September 2004, SAIC conducted a supplemental investigation to assess current conditions and to fulfill potential data gaps. Photographs from this investigation are provided in Appendix B. Data reports from this investigation are provided in Appendix C. Laboratory data sheets for the 2004 investigation may be found in the project record on file with the USFS.

#### *2.2.1 Surface Water*

This section provides a brief summary of the SI surface water data supplemented by data collected in 2004. Detailed analytical results are provided in the SI. Specifically, surface water sample results for filtered (dissolved) constituents are presented in Table G-1 of the SI report and unfiltered (totals) data are presented on page 148 of the SI report. The 2004 Site water sample results are provided in a summary table of Appendix C of this EE/CA. Sample locations are shown on Figures 1 and 2 of the SI report.

**Clear Creek.** Five surface water samples were collected by EA Engineering (2003) in Clear Creek in the near vicinity of the Site, and two background reference samples were collected upstream of the Blackjack Mine Site. Antimony, cadmium, cobalt, copper, total mercury, nickel, and selenium were not detected in any Creek samples. Only barium exceeded initial risk-screening values in the SI; however, the barium concentrations were within the upstream background values. The average hardness of Clear Creek water adjacent to the Site is 106 mg/L $CaCO_3$. The field pH values in this reach of Clear Creek indicated somewhat alkaline conditions, ranging from 7.61 to 8.42 standard units.

**Adit.** Two water samples were collected from the Site adit (one in 2003 inside the adit and one in September 2004 at the discharge point). The concentrations of barium, cobalt, iron, manganese, mercury, nickel, and zinc exceeded SI ecological screening values in both samples (2003 and 2004 sampling events). The pH of the mine water was 5.13 in 2004 and 5.2 in 2003. The Bluebird mine water discharges approximately 16 pounds of iron per day (lbs/day) into the settling pond and 5 lbs/day of manganese. The combined loading for arsenic, cadmium, chromium, cobalt, lead, mercury, nickel, selenium, and zinc is less than 1 lb/day.

**Settling Pond.** Three pond water samples were collected by EA Engineering. One sample was collected at the Red Boy discharge point in a pond west of Grant County Road 24, the second was collected in the same pond at the former Site discharge point, and the third sample was collected west of FS Road 10 at the downstream end of the pond on USFS administered land near a culvert. Aluminum, barium, cadmium, cobalt, iron, manganese, nickel, and zinc were identified in the SI as exceeding one or more conservative risk-screening values. The water chemistry data for total metals indicate that aluminum, iron, and manganese are precipitating out in the pond and the water is becoming oxidized.

There is a concern that some of the pond water may eventually flow back into Clear Creek, especially if the culvert downstream of the Site discharge pipe becomes unplugged. Table 1 compares selected water quality parameters from the adit drainage with the pond water quality near the culvert. The data in Table 1 indicate that iron is indeed settling in the ponds as a result of oxidation and generation of hydrogen ions that is related to lower pH and alkalinity of the pond water near the culvert. The data further indicate that iron, manganese, and nickel exceed water quality benchmark values.

It is likely that water quality in the pond would vary seasonally due to rainfall/runoff, snow melt, and potential changes in mine water chemistry. There are data gaps regarding the potential long-term effect of pond water that could enter Clear Creek, particularly if the culvert is unplugged. These data gaps include discharge rates, infiltration rates into the gravel floodplain, evaporation rates, and variability in water chemistry.

### *2.2.2 Sediment*

Six sediment samples were collected by EA Engineering (and co-located with the surface water samples) in Clear Creek adjacent to the Site. Three background sediment samples were collected upstream of the Site. The sediment samples are representative of only the fine fraction of the substrate habitat. Most of substrate of Clear Creek is comprised of gravels, cobbles, and boulder-sized materials. Most of the streambed has been physically altered to a substantial degree as part of the recent salmon restoration program.

**Table 1: Comparison of Bluebird Adit Water and Pond Water Quality**

| Parameter | Bluebird Adit Drainage | Pond Water near Culvert[a] | Water Quality Screening Values[b] |
|---|---|---|---|
| pH | 5.2 | 4.8 | 6.0 |
| Hardness | 148 | 228 | N/A |
| Specific Conductance | 192 | 414 | N/A |
| Alkalinity | 6.8 | 1.9 | N/A |
| Iron Total | 37,500 | 1,920 | 1,000 |
| Iron Dissolved | 7,340 | 1,310 | 1,000 |
| Manganese Total | 4,750 | 4,960 | 120 |
| Manganese Dissolved | 4,790 | 4,930 | 120 |
| Mercury Dissolved | 0.23 | 0.27 | 0.77 |
| Nickel Total | 108 | 129 | 105[c] |
| Nickel Dissolved | 106 | 126 | 104[c] |
| Zinc Total | 202 | 192 | 241[c] |
| Zinc Dissolved | 198 | 192 | 238[c] |

a = Based on one SI sample collected at Blue-16, and includes upstream water from the Red Boy Mine
b = From Table B-1
c = Based on Federal chronic criteria at hardness of 228 mg/L.

Arsenic, total chromium, copper, and nickel were noted in the SI for exceeding conservative sediment benchmark levels; however, none of these metals were notably above concentrations detected in the reference upstream samples.

One sediment sample was also collected at the downstream end of the Site settling pond. This sample was notably elevated relative to the sediment benchmark values (Appendix A-2, Attachment B, Table B-2). The pond sediment concentrations (in mg/kg) for Arsenic, iron, manganese, nickel, and zinc were 279; 459,000; 178,000; 1,300; and 1,470 mg/kg, respectively. These concentrations are largely due to the precipitation of iron oxide and oxyhydroxide metal complexes from the mine water. Detailed analytical results are provided in the SI, Table G-3. No additional sediment samples were collected in 2004.

### *2.2.3 Groundwater and Pore Water*

Groundwater in the vicinity of the Site is not used as a drinking water source. Thus, the groundwater exposure pathway is considered to be incomplete. Additional investigation and characterization of deep groundwater is not warranted.

Due to the potential for chemicals from the settling pond water to migrate through the substrate and enter Clear Creek, nine pore water samples were collected from the Creek adjacent to the Site. Two reference pore water samples were collected upstream of the Site. Pore water data are presented in Table G-2 of the SI report. Barium and mercury exceeded SI ecological screening values. The mercury concentrations (less than 0.17 µg/L) were below the USEPA screening value of 0.77 µg/L for protection of aquatic organisms but not below the Oregon bioaccumulation value of 0.012 µg/L. Hardness and pH of the Creek pore waters were similar to the co-located surface water samples.

### *2.2.4 Air*

The most likely source of air emissions from the Site would be particulate matter blowing off the waste piles. However, most of the waste rocks are too large to be mobilized by wind, so data on particulate matter emissions from the waste piles were not collected. Remediation of the site should address dust concerns that could affect remedial workers.

### *2.2.5 Soil/Waste Material*

Nine soil/waste samples were collected from the Site as part of the SI, along with two background soil samples. One sample collected within the adit portal was not considered as representative for soil exposures in the risk assessment portion of this EE/CA. Two additional composite samples from seven locations each were collected in September 2004 from the northwest mine rock area and the south mine dump, and one discrete sample was collected from the former mill area. Levels of aluminum, antimony, arsenic, cadmium, total chromium, copper, lead, manganese, mercury, nickel, selenium, thallium, vanadium, and zinc were above the preliminary screening values in the SI. Detailed analytical results are provided in Table G-4 of the SI, and the 2004 data is provided in the summary tables of Appendix C of this EE/CA. The highest concentrations of antimony (46 mg/kg), arsenic (165 mg/kg), mercury (82 mg/kg), and silver (53 mg/kg) were found in a sample above a wooden floor in the southeast corner of what appears to be a former mill site (See Figure 1). The volume of this material was estimated to be approximately 22 cubic feet (covering an area of approximately 18 sf) and vegetation was growing over this small waste source.

Since a mineral processing mill had been reported at this site, a careful inspection of the adjacent settling pond bottom was made to determine if it contained any mill tailings. Test holes were dug to depths ranging from 1.75 feet to 2.0 feet. In each of the holes, the bottom was found to be composed of native valley gravels with varying amounts of ferrous and ferromanganese staining. No materials having the appearance or consistency of tailings were detected at the pond.

**Dark Stained Gravel Area.** An area of exposed gravels exists just north of the old settling pond. The gravels are dark in color, assumed to be stained as a result of a diesel spill from an old dredge that may have occurred during the mid 1900s. A review of the SI report indicated that two soil samples were collected from this area. One sample was collected from the dark layer and the second was collected from the reddish sediments above it. The samples were both tested for gasoline and diesel range petroleum hydrocarbons and for polynuclear aromatic hydrocarbons (PAHs). No detectable concentrations of any petroleum hydrocarbon compounds were found in the dark layer sample. However, the sample collected from the A and B soil horizons had reported oil and grease at 36 parts per million. This number is considered an estimate because it was below the laboratory reporting limit.

Field inspection of both the light and dark colored material by SAIC on September 8, 2004 found no petroleum hydrocarbon odors in either of the layers. No evidence of any petroleum hydrocarbons was found. As a further check, SAIC collected a confirmatory sample from the black layer on October 5, 2004. The results for diesel range organics were also below detection limits using EPA Method 8021. The one slight detection in the upper layer from the 2003 sample was most likely due to naturally occurring organic compounds found in vegetative matter.

Careful field inspection of the dark colored layer found that the dark color was caused by a thin coating on the individual particles. The coating appeared inorganic and had the appearance of normal ferromanganese staining. The analytical data for these samples indicate that the iron and manganese concentrations were in the proper concentration range for what was being observed in the field. A portion of the material was also evaluated under a binocular microscope to allow better observation of the coatings. The coatings were found to be fine-grained in nature and had a sooty appearance. The coatings were then tested by spectrographic analysis. The results of these tests showed the coatings to contain high concentrations of iron and manganese. Based on these results, it is concluded that the coatings are predominantly composed of manganite and limonite; both common hydrated metal oxides found in shallow reducing environments.

**Waste Rock Piles.** In determining the nature and extent of potential contamination, volume estimates are needed for remedial actions to occur. The SI report estimated that there were 9 cubic yards of waste rock located at the southern end of the old sediment pond, 350 cubic yards located west of the portal along the east side of Clear Creek, and 2,238 cubic yards located in the large pile to the south of the mine portal, for a total of 2,597 cubic yards. Based on the 2004 field investigation, SAIC estimated a significantly higher total waste rock volume of approximately 6,000 cubic yards. This volume was calculated using the 2-foot contour interval survey map provided to SAIC by the USFS. The original ground surface below the waste rock piles were projected in and the volumes estimated based on the volume differences. SAIC's volume accuracy is estimated to be plus or minus 20 percent. If additional precision would be desired, the contact of the waste rock pile with the original underlying ground surface would need to be accurately located, either by drilling or using appropriate geophysical methods. For the purposes of this EE/CA the estimated total of 6,000 cubic yards includes the south waste rock pile (approximate horizontal dimensions of 150 feet by 60 feet with a maximum height of about 25 feet), the west waste rock pile located on the west side of the old diversion cut, and the small waste rock pile located on the hillside directly to the north of the cut.

#### *2.2.6 Plant Tissue*

Two plant tissue samples of wild strawberry were collected from the site, one from the south waste pile and one from the western portion of the site near the Clear Creek floodplain. Aluminum, iron, mercury, and zinc levels were slightly elevated in the site tissue samples relative to the reference background tissue samples. Tissue data are presented in Table G-5 of the SI report.

## 3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT

### 3.1 Streamlined Human Health Risk Evaluation

A human health risk evaluation (HHRE) is a streamlined 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 HHRE incorporates analytical data and information on potential exposure pathways gathered during the SI and EE/CA, and uses default exposure assumptions where applicable to develop risk estimates for this site. The HHRE was performed in accordance with Oregon DEQ and USEPA guidance (ODEQ 2000, USEPA 1989).

Primary elements of the HHRE are as follows:

- **Identification of contaminants of potential concern:** Evaluation of site data and identification of elevated concentrations of contaminants in site media.

- **Exposure assessment:** Development of a conceptual site model and identification of potential exposure pathways under current and future land uses, and development of a quantitative estimate of exposure.

- **Toxicity assessment:** Identification of toxicity values for use in quantifying carcinogenic and noncarcinogenic risks associated with exposure to site-related chemicals.

- **Risk characterization:** Development of quantitative risk estimates using potential exposure and toxicity information previously developed for the contaminants of potential concern (COPCs).

### *3.1.1 Contaminants of Potential Concern*

All data collected during the site investigations were screened using the Oregon Department of Environmental Quality (ODEQ) screening protocol (ODEQ 2000). The screening results are presented in Appendix A, Part 1, Attachment A. Twenty three metals were identified as Chemicals of Interest (COIs) for the Site: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

As allowed by ODEQ guidance, COIs were eliminated if the frequency of detection was less than 5 percent or if they were detected at concentrations less than background levels.

Maximum concentrations of the remaining COIs were screened against Environmental Protection Agency (EPA) Region IX Preliminary Remediation Goals (PRGs; USEPA 2004a). In addition to individual screening, ODEQ requires consideration of multiple chemical COPCs and, where more than one medium is contaminated, multiple media COPCs. Industrial PRGs were selected as the most appropriate screening criteria for soils and sediment. Because there are no industrial PRGs for water, tap water PRGs were used to represent a very conservative screen for surface water.

The following COPCs were identified for the Site:

- Soils/wastes: arsenic, iron
- Surface water: arsenic
- Sediment: aluminum, arsenic
- Multiple media: aluminum, arsenic, iron

### *3.1.2 Exposure Assessment*

At the Site, a recreational visitor camping in the vicinity of the site was identified as the most conservative (i.e., health protective) scenario. Exposure to COPCs was evaluated for incidental ingestion of and dermal contact with surface soil, waste rock and sediment, inhalation of airborne particulates, and ingestion of surface water as a drinking water source. In addition, since maintenance workers may be involved in maintenance at the site for 1 or 2 days per year, potential exposure to COPCs by a maintenance worker was also evaluated in this HHRE. Exposure assumptions include factors such as body weight, averaging time, exposure frequency, and exposure duration. For purposes of this streamlined HHRE, calculations were performed using reasonable maximum exposure (RME) default exposure assumptions, based on EPA and ODEQ guidance. All exposure assumptions are presented in Appendix A, Part 1.

Because the RME scenario is evaluated in the HHRE, statistical analysis and calculation of the 90 percent upper confidence level (UCL90) on the mean were used to estimate the EPC. If the UCL90 was greater than the maximum detected concentration, then the maximum detected concentration was used as the EPC.

### *3.1.3 Toxicity Assessment*

The objectives of the toxicity assessment were to evaluate the inherent toxicity of the COPCs and to identify and select toxicity values for use in calculating human health risk. Toxicity values are used to quantify the relationship between the level of exposure to a COPC and the potential increased likelihood and/or severity of adverse health effects. The sources used to obtain toxicity information and methods for deriving toxicity criteria are presented in Appendix A, Part 1.

Both cancer and noncancer health effects were evaluated quantitatively. Dose-response estimates are presented as reference doses (RfDs) for noncarcinogenic effects (those not related to cancer) and cancer slope factors (SFs) for carcinogenic effects

### *3.1.4 Risk and Hazard Estimates for the Recreational Receptor*

The HHRE results for a recreational visitor are summarized below.

| COPC | Excess Cancer Risk | Hazard Index |
|---|---|---|
| Aluminum | NA | 0.0007 |
| Arsenic | 2E-6 | 0.03 |
| Iron | NA | 0.005 |
| Total | 2E-6 | 0.04 |

Risks are discussed below.

- *Soils/Wastes and Sediment:* Cancer risks to a recreational visitor from arsenic in soils, waste rock, and sediment are below 1E-6. Noncancer hazards are less than 1. This level of risk is considered acceptable

- *Surface Water:* The cancer risk due to the presence of arsenic in surface water slightly exceeds the acceptable risk level for a single chemical of 1E-6. It should be noted that arsenic was detected in only one of 11 surface water samples, and the exposure point concentration (EPC) of 2.4 µg/L is likely to substantially overestimate the mean concentration. In addition, the drinking water Maximum Contaminant Level (MCL) for arsenic is 10 µg/L, which is significantly higher than the concentration of arsenic in Clear Creek. Therefore, arsenic in surface water is not believed to pose an unacceptable risk to recreational visitors.

### *3.1.5 Risk and Hazard Estimates for the Maintenance Worker*

Risk results for the maintenance worker are summarized below.

| COPC | Excess Cancer Risk | Hazard Index |
|---|---|---|
| Aluminum | NA | 0.00008 |
| Arsenic | 2E-7 | 0.001 |
| Iron | NA | 0.0006 |
| Total | 2E-7 | 0.002 |

Cancer risks and noncancer hazards to maintenance workers do not exceed levels of concern for any of the exposure pathways evaluated.

### *3.1.6 Determination of Hot Spots*

An assessment of hot spots is performed by comparing the concentration of a site contaminant to its "highly concentrated" hot spot level, defined as the concentration corresponding to a lifetime cancer risk of 1E-4 for carcinogens and a hazard quotient of 10 for noncarcinogens.

No contaminants were present at levels above their "highly concentrated" hot spot level.

### *3.1.7 Human Health Risk Evaluation Summary*

The human health conceptual site model is presented in Figure 1 of Appendix A. Part 1. Of the 23 COIs detected at the Site, only aluminum, arsenic, and iron were identified as COPCs. Exposure to these three chemicals was evaluated quantitatively in this HHRE. Based on current and projected future land use, individuals who may come in contact with site-related contaminants during recreational activities such as camping and hiking were identified as potential receptors. In addition, USFS employees or contract workers involved in maintenance of culverts and drainpipes were also identified as potential receptors. Results of the HHRE indicate that the potential for carcinogenic and noncarcinogenic human health impacts resulting from exposure to site contaminants is low. With the exception of a single surface water sample, concentrations of constituents in soils, waste rock, surface water, and sediment did not exceed the regulatory standards, and therefore risk-based cleanup goals were not calculated. Arsenic was detected in surface water in only one of 11 samples, at an estimated concentration of 2.8 µg/L, which is below the drinking water MCL of 10 µg/L.

## 3.2 Streamlined Ecological Risk Assessment

This section summarizes the Streamlined Ecological Risk Assessment (ERA) that is presented in Appendix A, Part 2. The ERA was conducted in accordance with ODEQ guidance (ODEQ, 2001) and consistent with EPA guidance (USEPA 1997, 1998). The purpose of the streamlined ERA is to provide an understanding of the potential for ecological risks due to mine-related contamination and to determine whether there is a need for more detailed ecological risk assessment. The ERA provided a discussion of the following components:

- A problem formulation that includes identification of contaminants of interest (COIs) based on site uses and existing data
- A description of the ecology of the site and potential ecological receptors (including rare, threatened, and endangered species) at or near the site
- A conceptual site model that provides a summary of potential exposure media and pathways
- Assessment and measurement endpoints
- Risk screening of the COIs in each media to identify contaminants of potential ecological concern (CPECs)
- Risk characterization to assess the potential for significant ecological effects due to site-related contaminants

Ecological conditions were documented in the SI report and during supplemental site visits on September 8-10 and October 5, 2004 by SAIC. An ODEQ ecological scoping checklist was also completed and is provided with the ERA.

The conceptual site model presented in Figure 2 of Appendix A, Part 2 outlines the sources of contamination, contaminant release and transport mechanisms, impacted exposure media, and exposure routes for ecological receptor types at the site. Threatened salmonids, other fish, and macroinvertebrate communities of Clear Creek could be adversely exposed to contaminants from major failures of the existing discharge pipe or of the side channels that receive the mine water. Aquatic organisms in the Creek may also be exposed to discharge of contaminated shallow groundwater reentering from the side channel ponds or from erosion of mining-related wastes into the Creek in the vicinity of the former settling pond on the east bank.

Plants growing on contaminated soils or waste materials may uptake and bioaccumulate chemicals that may become toxic or could be transferred through the food web. Local small mammals and ground birds (e.g., grouse) may be exposed to contaminants in waste rock piles and from the former mill site area. Larger mammals and birds with greater home ranges may occasionally be exposed to the mine waste rock.

### *3.2.1 Summary of Risks to the Aquatic Ecosystem*

There were no contaminants of interest identified in Clear Creek surface waters and pore waters. Copper, iron, and mercury were identified as CPECs in Clear Creek sediments; however, their risk ratio (the exposure concentration divided by the sediment screening value) ranged from 1.1 for mercury to 1.3 for iron. These low risk ratios suggest that the fine sediment fraction in the Creek does not pose an adverse risk or threat to aquatic resources. Fish population data, macroinvertebrate community data and aquatic habitat assessment data were also evaluated in the ERA and by the weight-of-evidence approach, it was concluded that Clear Creek is not currently being impacted by the existing configuration of the drainage system and settling pond at the Site.

However, the current configuration is dependent on a plugged culvert at the downstream end of the sediment pond just before the mine water flows onto private property. Should the culvert become unplugged, it is likely that some of the mine water and associated precipitates would reenter Clear Creek. Although, the extent of risk to the creek is unknown and cannot be adequately predicted from existing site data, it would be expected to be adverse in the long-term for the following reasons: (1) the concentrations of iron and nickel in discharged pond water exceed federal water quality criteria, (2) the high concentrations of manganese in the low pH pond water would likely precipitate upon mixing with Clear Creek water, resulting in potential localized smothering of gravels and increased embeddedness, and (3) the potential for typical storm events to wash other accumulated precipitates in the floodplain east of the County Road directly into the creek.

### *3.2.2 Summary of Risks to the Terrestrial Ecosystem*

The ODEQ risk screening methodology for terrestrial receptors was used in the streamlined ERA. Concentrations of chemicals of interest in the soil/waste materials were compared with soil screening values for four terrestrial receptor groups (plants, invertebrates, birds, and mammals). Risk ratios were determined for several source areas: 1) the northwest waste rock area, (2) south waste rock pile, (3) former mill site area, (4) iron precipitate in gully, and (5) other soil sample areas.

The highest risk ratios were from mercury, arsenic, antimony, and silver in the sample from the former mill site. These ratios ranged from 9 for antimony to 820 for mercury, suggesting the likelihood of adverse risks to local terrestrial receptors. Because mercury is very bioaccumulative, the threat for mercury to enter the food chain is also of concern. However, the volume of this material is only about 22 cubic feet and vegetation is growing over the material. The actual risks to terrestrial wildlife from this source would be minimal.

Although the iron precipitate in the gully has risk ratios exceeding 1 for arsenic, iron, mercury, selenium, and thallium, the volume of material is very small – approximately 20 cf. Risk ratios for ecological receptors that utilize the northwest waste rock area and the south waste rock pile were relatively low (ratio <5) with the avian receptor group being more sensitive to arsenic and lead.

The physical characteristics of the rock material or iron precipitate in the former settling pond lack soil horizons and nutrients. Consequently the material does not provide quality habitat for soil organisms or vertebrates to utilize these source areas. The plant tissue data from the site did not show unusual levels of metals uptake, with most metals being within background tissue concentrations. Leach testing of the waste piles indicate that contaminant release potential is low and not of regulatory concern and indicate that the elevated metal concentrations in the rock material has low potential for bioavailability to terrestrial receptors. Given these conditions, the relatively low risk ratios, and small volumes of waste materials within a small site (< 1.5 acres), the ERA concluded that risks to terrestrial receptors is considered low and would not cause adverse population effects to wildlife of the area.

# 4.0 SITE CLEANUP CRITERIA

## 4.1 Applicable or Relevant and Appropriate Requirements

Applicable or Relevant and Appropriate Requirements" (ARARS) are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) site. CERCLA requires that remedial actions attain ARARs to the extent practicable, considering the urgency of the situation and the scope of the action. ARARs are either applicable or relevant and appropriate.

**Applicable:** A requirement is applicable if the jurisdictional prerequisites of a standard correspond to conditions at the site. Most hazardous waste and material regulations were developed to address active industrial operations and industrial waste disposal activities and, for the most part, were not intended to address remediation after mismanagement had occurred. Therefore, many regulations and statutes are not directly applicable to CERCLA activities, but do contain language that addresses CERCLA site conditions, contaminants, and/or actions that are similar to the intent of the original regulations.

**Relevant and Appropriate:** Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, are not applicable, but address situations similar to the proposed response action and site conditions. Only those state promulgated requirements that have been identified in a timely manner, consistently applied, and are more stringent than federal requirements would be considered relevant and appropriate.

Although non-promulgated advisories or guidance issued by federal or state government are not legally binding and do not have the status of ARARs, such requirements may be useful and may be considered. "To be considered" (TBC) requirements complement ARARs but do not override them. They are useful for guiding decisions on cleanup levels or methodologies for which regulatory standards are not available. TBCs are included in this analysis in the form of ecological and human health risk benchmark values.

ARARs are chemical, location, or action-specific:

*Chemical Specific*. Chemical specific ARARs include laws and regulations that regulate the release of hazardous chemicals to the environment. These requirements generally set health or risk based concentration limits or discharge limitations for specific compounds. Many chemicals, particularly in soils, wastes, and sediments, do not have regulatory action levels (i.e., levels above which remediation is required) specifically addressed by ARARs. Therefore, a risk assessment may be performed to identify an action level for a contaminant based on a level of “acceptable” risk defined for the site. The results of a risk assessment can be used as an enforceable standard for remediation of a site.

*Location Specific*. Location specific ARARs are requirements related to the geographical location of the site (e.g., state regulations) or physical condition of the site (e.g., if the site is in a coastal area, then coastal regulations may apply), and may limit the type of remedial actions that can be implemented.

*Action Specific*. For the most part, these ARARs are technology- or activity-based requirements, or limitations on actions taken to remediate hazardous waste sites. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. These action-specific requirements do not identify the remedial alternative; rather, they indicate how a selected alternative should be achieved.

Table 2 (following the text) summarizes ARARs by chemical-specific, location-specific, or action-specific regulation.

### 4.2 ARAR-Based Preliminary Removal Goals (PRGs)

The primary ARAR guiding removal actions at the Site is the National Recommended Water Quality Criteria: 2002 (USEPA 2002). Actions to date at the Site have piped the adit drainage to a settling pond and away from Clear Creek. ESA-listed Chinook salmon utilize Clear Creek for spawning and rearing. The Endangered Species Act is considered a primary ARAR as well.

### 4.3 Risk-Based PRGs

According to OAR 340-122-040, removal actions shall be implemented to achieve 1) acceptable risk levels as demonstrated through site-specific risk assessment for both human and ecological receptors; 2) background concentrations for naturally occurring substances; or 3) numeric soil cleanup levels specified in OAR 340-122-045 and the EPA Region 9 PRGs. Because the streamlined human health risk evaluation did not indicate that there were unacceptable risks to humans, a risk-based PRG for humans was not developed. Furthermore, the soil cleanup levels and EPA Region 9 PRGs are screening levels that were used in the risk assessment and are not considered appropriate cleanup levels.

As outlined in the streamlined ecological risk assessment, State of Oregon soil ERBSC’s would be highly overprotective of ecological receptors. In addition, population-level effects could only occur for ecological species if the receptors were to forage predominantly at the Site. Considering the localized and small exposure areas, this is unlikely. Furthermore, the habitat lost due to any effects on plants is also unlikely to result in significant effects to upper trophic level species due to the large amount of relatively undisturbed habitats available surrounding the Site. Therefore, risk-based PRGs for ecological receptors were not developed.

## 5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

### 5.1 Scope, Goals and Objectives of the Removal Action

The scope of the removal action is to achieve closure of the Site while attaining ARARs to the extent practicable.

The goal of the removal action for the Site is to achieve final cleanup of mining-related materials to acceptable levels of risk to humans and the environment. As described in the human health risk evaluation, there are no adverse hazards or risks to humans. The ecological risk assessment described the potential threat to Clear Creek (and its threatened salmonids) in the event of discharge of water and metal precipitates from the settling pond.

Since the evaluation in this EECA indicates that the scope and goal of the removal action are met with respect to mine waste rock areas and soils, no objectives for the removal action were developed and a detailed analysis of removal action alternatives was not performed.

With respect to protecting Clear Creek, there are two broad-based preliminary removal action objectives: (1) Meet the applicable Oregon water quality standards in Clear Creek and maintain long-term compliance with the standards, and (2) prevent or control releases of hazardous substances from the settling pond into Clear Creek.

Currently, water quality criteria are being met under the existing configuration that includes a plugged culvert. However, as stated in Section 3.2.1 and in the ecological risk assessment, major data gaps occur with respect to evaluating alternatives related to unplugging the culvert and allowing pond water and some accumulated sediments to enter Clear Creek. Additional data include, but are not limited to: the volumes of such a release, pond water quality, the time-frame for a culvert release (e.g., outside the salmon migration window), the magnitude of release, the predicted water levels in the pond after controlled or uncontrolled releases, infiltration rates of pond water into the floodplain gravels, and flow rates of both Bluebird and Red Boy adit discharges. Consequently, these data will need to be collected prior to development of serious alternatives that address the settling pond discharge issue.

## 6.0 CONCLUSION AND RECOMMENDATION

Because unacceptable hazards and risks to human health are not expected, and terrestrial ecological receptors would not be adversely affected, no further environmental action is warranted for waste rock areas. In accordance with 40 CFR 300.410(e)(2)(f)(5), this EE/CA process is completed for soils and waste rock areas because the amount, quantity, or concentrations released do not warrant further response at this time.

The USFS is in the process of collecting additional information regarding mine water flow rates and water quality measurements. The new pipeline system to control mine drainage is currently protective of aquatic resources in Clear Creek under the existing configuration. However, additional data is necessary prior to development of alternatives regarding pond water discharge. Therefore, a supplemental EE/CA or and addendum to this EE/CA should be prepared after a thorough evaluation of data needs are developed regarding pond discharge, and after the data are collected and analyzed.

## 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 Forest Service has conducted a PRP search relating to this site and has been unable to identify any current claimants or viable PRPs at this time. 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.

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Prepared by:

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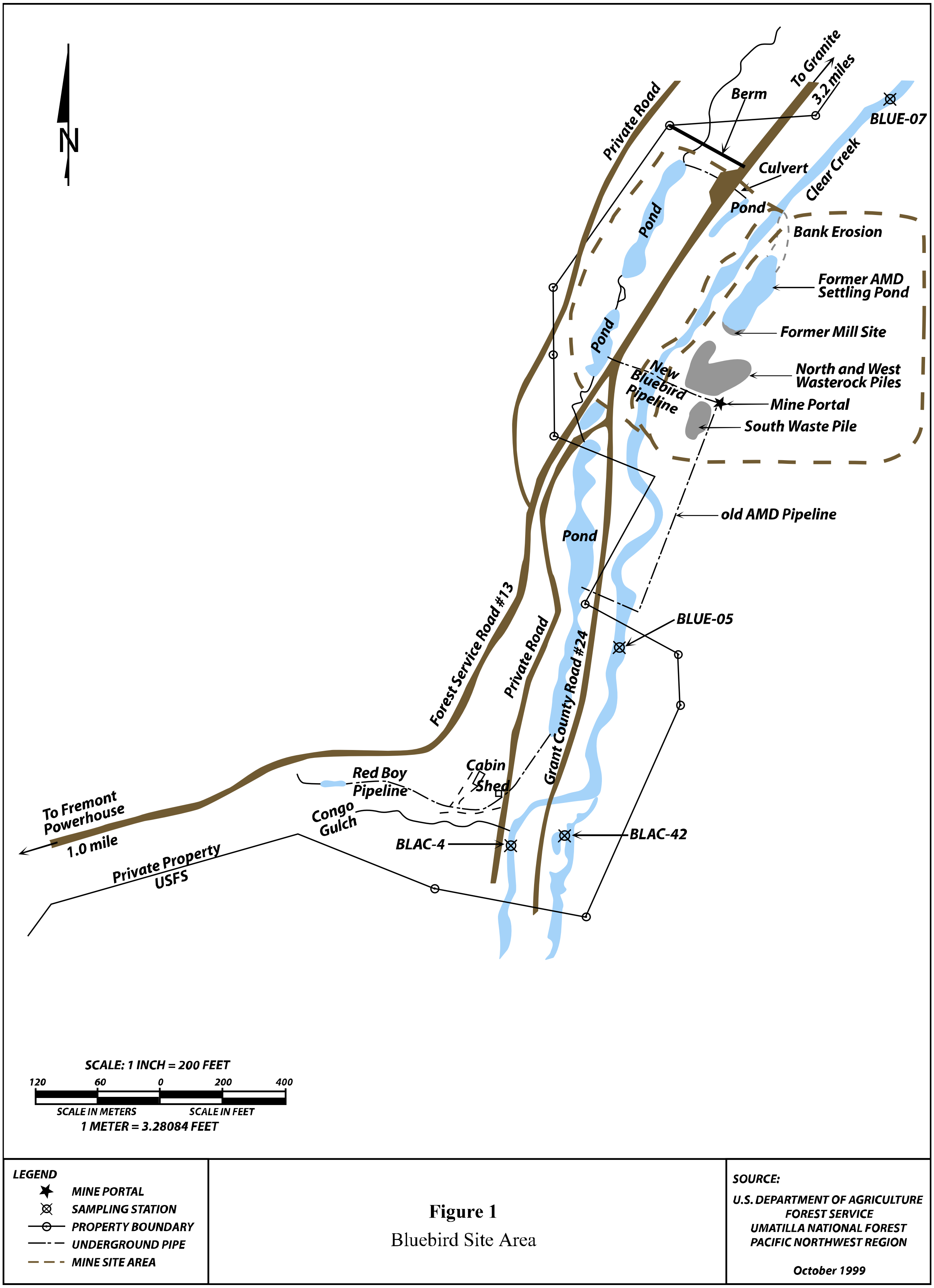


**Figure 1**
Bluebird Site Area

**TABLES**

**Table 2: Potential ARARs for Bluebird Mine Site**

| Standard, Requirement Criteria, or Limitation | Citation | Description | Applicable/Relevant and Appropriate? |
|---|---|---|---|
| **Chemical Specific ARARs** | | | |
| **FEDERAL** | | | |
| **Safe Drinking Water Act** | 40 USC § 300 | | |
| National Primary Drinking Water Regulations | 40 CFR Part 141 | Establishes health-based standards, maximum contaminant levels (MCLs), for public water systems. | Not an ARAR, groundwater has been eliminated from the removal action. |
| National Secondary Drinking Water Regulations | 40 CFR Part 143 | Establishes aesthetic standards (secondary MCLs) for public water systems. | Not an ARAR, these are not enforceable standards and are outside scope of removal action. |
| **Clean Water Act** | 33 USC §§ 1251 - 1387 | | |
| National Ambient Water Quality Criteria | 40 CFR Part 131 | Sets criteria for water quality based on toxicity to aquatic organisms and human health. | Not an ARAR since the State of Oregon has been delegated this program. |
| **Clean Air Act** | 40 USC § 7409 | | |
| National Primary and Secondary Ambient Air Quality Standards | 40 CFR Part 50 | Establishes air quality levels that protect public health. | Not an ARAR – only "major" sources are subject to requirements related to NAAQS, defer to state regulation of fugitive dust emissions. |
| **Resource Conservation and Recovery Act** | 40 USC § 7601 | | |
| Lists of Hazardous Wastes | 40 CFR Part 261, Subpart D and C | Defines those solids wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271. | Not an ARAR – mine waste is not a listed hazardous waste, Bevill exempt. Even if TCLP testing confirmed a characteristic waste (Subpart C), it is still exempt. Parts of the RCRA |

| Standard, Requirement Criteria, or Limitation | Citation | Description | Applicable/Relevant and Appropriate? |
|---|---|---|---|
| | | | regulations may be relevant and appropriate, however, and are discussed under action-specific requirements. |
| **STATE OF OREGON** | | | |
| Hazardous Substance Remedial Action Rules | OAR 340-122-84 and 1-115 | Establishes DEQ Guidelines for assessing human health and ecological risk assessments on potential adverse affects from contamination according to DEQ risk guidelines and levels. | Relevant and Appropriate Requirement |
| Preliminary Remediation Goals (PRGs) for soil and water | US Environmental Protection Agency (EPA) Region 9 | Preliminary Remediation Goals (PRGs) are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements. The PRGs contained in the Region 9 PRG Table are generic; they are calculated without site specific information. However, they may be re-calculated using site specific data. PRGs should be viewed as Agency guidelines, not legally enforceable standards. They are used for site "screening" and as initial cleanup goals if applicable. | Relevant and Appropriate Requirement |
| Hazardous Substance Occupational Exposure | OAR 437 | Establishes OR-OSHA Permissible Exposure Limits (PELs). OR-OSHA exposure limits mirror the federal chemical specific limits (refer to NIOSH Pocket Guide to Chemical Hazards for details on individual chemicals) | Relevant and Appropriate Requirement |
| Numeric Soil Cleanup Levels for Motor Fuel and Heating Oil | OAR 340-122-305 through 360 | Establish cleanup standards for contamination of soil by motor fuel and heating oil. | Not an ARAR |
| Oregon Soil Cleanup Rules for Simple Sites | OAR 340-122-045 and 046 | Establishes DEQ rules for streamlined cleanup processes and numerical cleanup standards at | To Be Considered |

| Standard, Requirement Criteria, or Limitation | Citation | Description | Applicable/Relevant and Appropriate? |
|---|---|---|---|
| | | simple sites. | |
| State of Oregon is authorized by the USEPA to implement the Clean Water Act in Oregon | Clean Water Act – FWQC 40 CFR | Establishes acceptable contaminant levels for ingestion of aquatic organisms and for intake by aquatic organisms in surface water. | Applicable Requirement |
| Asbestos Removal | OAR 340-32-5620 through 5650 | Establish DEQ requirements for licensing and certification for asbestos workers. All workers who handle asbestos-containing materials must meet certain training, licensing and certification requirements. | Not an ARAR |
| **Location-Specific ARARs** | | | |
| **FEDERAL** | | | |
| **Resource Conservation and Recovery Act** | 40 USC § 7601 | | |
| Hazardous and Solid Waste Regulations | 40 CFR Part 264.18 | Location standards and restrictions for hazardous waste treatment, storage, and disposal (TSD) facilities. | Not an ARAR, no materials are being disposed. |
| | 40 CFR §§ 257.3-1 through 257.3-4 | Location standards and restrictions for municipal solid waste (MSW) facilities. | Not an ARAR, no materials are being disposed. |
| **National Historic Preservation Act** | 16 USC § 470; 36 CFR Part 800; 40 CFR 6.301(b) | Requires Federal Agencies to take into account the effect of any Federally assisted undertaking or licensing on any property with historic, architectural, archeological, or cultural value that is included in or eligible for inclusion in the National Register of Historic Places. | Applicable Requirement |
| **Archeological and Historic Preservation Act** | 16 USC § 469 40 CFR 6.301(c) | Establishes procedures to provide for preservation of significant scientific, prehistoric, historic, and archeological data that might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed | Applicable Requirement |

| Standard, Requirement Criteria, or Limitation | Citation | Description | Applicable/Relevant and Appropriate? |
|---|---|---|---|
| | | activity or program. | |
| **Protection of Wetlands Executive Order No. 11990** | 40 CFR Part 6; Appendix A, 40 CFR 6.302(a) | Avoid adverse impacts associated with the destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists. | Applicable Requirement |
| **Dredge and Fill Regulations** | 33 USC § 1344, 33 CFR 323.1 et. seq. | Prohibits discharge of dredged or fill material into waters of the United States without a permit | Relevant and Appropriate Requirement |
| **Fish and Wildlife Coordination Act** | 16 USC Chapter 49, §§ 2901-2912; 40 CFR 6.302(g) | Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body to assure adequate protection of fish and wildlife resources. | Not an ARAR – no stream modification is contemplated for this removal action. |
| **Floodplain Management Executive Order No. 11988** | 40 CFR Part 6, Appendix A; 40 CFR 6.302(b) | Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain to the extent possible. | Applicable Requirement |
| **Endangered Species Act** | 16 USC §§ 1531-1543; 40 CFR 6.302 (h); 50 CFR Part 402 | Activities may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat. | Applicable Requirement |
| **Bald Eagle Protection Act** | 16 USC §§ 668 et seq. | Requires continued consultation with the USFWS during remedial design and remedial construction to ensure that any cleanup of the site does not unnecessarily adversely affect the bald or golden eagle. | Applicable Requirement |
| **Migratory Bird Treaty Act** | 16 USC §§ 703 et seq. | Establishes federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds. | Applicable Requirement |

| Standard, Requirement Criteria, or Limitation | Citation | Description | Applicable/Relevant and Appropriate? |
|---|---|---|---|
| **Action-Specific ARARs** | | | |
| **FEDERAL** | | | |
| **Clean Water Act** | 33 USC § 1342 | | |
| National Pollutant Discharge Elimination System | 40 CFR Part 122.26 | In general, Part 122 provides permit requirements for the discharge of pollutants from any point source into waters of the United States. Part 122.26 requires permits for storm-water discharges. | Applicable Requirement |
| **Surface Mining Control and Reclamation Act** | 30 USC §§ 1201-1328 | Performance standards for surface mining activities. | Relevant and Appropriate Requirement |
| **Hazardous Materials Transportation Act** | 49 USC §§ 1801-1813<br>49 CFR Parts 10, 171-177 | Regulates transportation of hazardous materials. | Not an ARAR, no materials are being hauled. |
| **Resource Conservation and Recovery Act** | 46 USC § 7601 | | |
| Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities | 40 CFR Part 264.13.14 | Requirements for proper handling, treatment, storage, and disposal of hazardous wastes. | Not an ARAR, no hazardous materials are being treated, stored, or disposed. |
| Land Disposal Restrictions (LDRs) | 40 CFR Part 268 | LDRs place specific restrictions (conc. or trmt) on RCRA hazardous wastes prior to their placement in a land disposal unit. Relevant and appropriate LDR requirements will be met if any material accumulations are treated ex situ. | Not an ARAR, no materials are being disposed. |
| Disposal of Solid Waste | RCRA 42 U.S.C. § 6901 et seq; 40 CFR 257 | Facility or practices in floodplains will not restrict flow of basic flood, reduce the temporary water storage capacity of the floodplain or otherwise result in a wash-out of solid waste. | Not an ARAR, no materials are being disposed. |

| Standard, Requirement Criteria, or Limitation | Citation | Description | Applicable/Relevant and Appropriate? |
|---|---|---|---|
| Closure Requirements | RCRA/HWMA 40 CFR & 264, Subpart G | Closure of hazardous waste repositories must meet protective standards. Regulations to minimize contaminant migration, provide leachate collection and prevent contaminant exposure will be met. | Not an ARAR. |
| Landfill Design and Construction | RCRA/HWMA 40 CFR & 264, Subpart N | Hazardous waste landfills must meet minimum design standards. Protectiveness will be achieved through capping and institutional controls. | Not an ARAR. |
| Ground Water Monitoring | RCRA/HWMA 40 CFR & 264, Subpart F 40 CFR & 264, Subpart X | Establishes standards for detection and compliance monitoring. Site wide monitoring will accommodate specific ground water monitoring requirements. | Not an ARAR, groundwater is not an impacted media. |
| **Occupational Exposure to Asbestos** | 29 CFR Parts 1910 and 1926. | Establishes OSHA requirements for asbestos-related work in the construction and demolition industry. Requirements on exposure limits, work practices and engineering controls to provide worker safety in handling, removal, disposal, or other workplace exposure to asbestos. | Not an ARAR. |
| **STATE OF OREGON** | | | |
| **Fugitive Dust Emissions** | 40 CFR Section 50.6 | Establishes standards for PM-10 | Applicable Requirement |
| **Asbestos Removal** | OAR 340-32-5620 through 5650 | Establish DEQ requirements for licensing and certification for asbestos workers. All workers who handle asbestos-containing materials must meet certain training, licensing and certification requirements. | Not an ARAR |
| | OAR 340-33-010 through 100 | Establish DEQ requirements for handling asbestos-containing materials. Handling, removing, transporting and disposing of asbestos material in a manner that prevents it from becoming friable and releasing asbestos fibers. | Not an ARAR. |

# Appendix A: Risk Assessments

## Bluebird Mine Site

**Appendix A-1: Streamlined Human Health Risk Evaluation**

**Bluebird Mine Site**

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## 1.0 INTRODUCTION

A human health risk evaluation (HHRE) was conducted at the Bluebird Mine Site (Site), located in Umatilla National Forest. The objective of this HHRE was to determine the potential for adverse health effects to human receptors that may be exposed to site-related contaminants in soil and waste rock, sediment, and surface water. The HHRE was conducted in accordance with Oregon Department of Environmental Quality (ODEQ 2000) and U.S. Environmental Protection Agency (USEPA) risk assessment guidance (USEPA 1989, USEPA 2004c).

The HHRE is a streamlined analysis of the potential adverse health effects that could result from current or future exposures to hazardous substances released from the site, in the absence of any action to control or mitigate these releases. The HHRE incorporates analytical data and information on potential exposure pathways gathered during the Site Inspection (SI) and Engineering Evaluation/Cost Analysis (EE/CA), and uses default exposure assumptions where applicable to develop risk estimates for this site.

The following are primary elements of the HHRE:

- **Identification of contaminants of potential concern:** Evaluation of site data and identification of elevated concentrations of contaminants in site media.

- **Exposure assessment:** Development of a conceptual site model and identification of potential exposure pathways under current and future land uses, and development of a quantitative estimate of exposure.

- **Toxicity assessment:** Identification of toxicity values for use in quantifying carcinogenic and noncarcinogenic risks associated with exposure to site-related chemicals.

- **Risk characterization:** Development of quantitative risk estimates using potential exposure and toxicity information previously developed for the contaminants of potential concern (COPCs).

## 2.0 HAZARD IDENTIFICATION AND SELECTION OF COPCS

This section presents the rationale for the selection of the contaminants of potential concern (COPCs). All data collected during the site investigations were screened using the Oregon Department of Environmental Quality (ODEQ) screening protocol (Guidance for Conduct of Deterministic Human Health Risk Assessments, ODEQ 2000). The screening results are presented in Attachment A. Twenty three metals were identified as Chemicals of Interest (COIs) for the Site: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

As allowed by ODEQ guidance, COIs were prescreened based on the following criteria:

- Frequency of Detection – COIs that were detected in less than 5 percent of the samples site-wide were not selected as COPCs. A number of chemicals in soil, sediment and groundwater were deleted on the basis of this criterion.

- Background – Naturally occurring chemicals detected at concentrations less than background were not selected as COPCs.

Several chemicals were eliminated from further consideration based on this prescreening. Tables A-1 through A-3 present the results of the prescreening.

Maximum concentrations of the remaining COIs were screened against USEPA Region IX Preliminary Remediation Goals (PRGs). In addition to individual screening, ODEQ requires consideration of multiple-chemical COPCs and, where more than one medium is contaminated, multiple-media COPCs. Industrial PRGs were selected as the most appropriate screening criteria for soils and sediment. Since there are no industrial PRGs for water, tap water PRGs were used to represent a very conservative screen for surface water.

In addition, essential nutrients (calcium, magnesium, potassium, and sodium) were eliminated as COPCs, as recommended by USEPA guidance (USEPA 1989).

Tables A-4 through A-7 present the chemical screening; Table A-8 summarizes the results of the screening process. The following COPCs were identified for the Site:

| | |
|---|---|
| Soils/Wastes: | arsenic, iron |
| Surface water: | arsenic |
| Sediment: | aluminum, arsenic |
| Multiple media: | aluminum, arsenic, iron |

## 3.0 EXPOSURE ASSESSMENT

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

### 3.1 Potentially Exposed Populations

The Site is currently inactive and covers an area of approximately 2 acres on moderate to steep hillsides adjacent to Clear Creek within Umatilla National Forest. It is not currently occupied, nor is it expected to be occupied or developed in the near future. The town of Granite, with a reported population of 24, is located about 2.75 miles from the site (EA Engineering 2003). The closest regularly occupied building appears to be located at the Red Boy Mine, approximately 0.25 mile from the Bluebird Mine. There are no onsite workers, and no people who live within 200 feet of areas of suspected site-related contamination.

Public use of the mine and vicinity is most likely minimal, although public access records are not maintained. While access is limited by the creek and moderately steep slopes, the site is physically accessible. There are no designated campsites near the site, but dispersed and/or primitive campsites may be located in the general site area.

There are no attractive ruins or structures on the site that would attract visitors, and the creek serves as an additional deterrent. Visitors would need to cross the creek in order to access the adit, waste piles, or possible former mill site. In addition, the site is a poor location for hunting due to its proximity to the road. Access is currently not restricted by fencing, nor were any "No Trespassing" signs noted during the site investigation. Impacts to ecological receptors are addressed in the ecological risk assessment.

To protect Chinook salmon, recreational fishing is prohibited in Granite Creek and its tributaries (including Clear Creek) by the Oregon Department of Fish and Wildlife (ODFW). Local Native American populations engage in ceremonial fishing in this area, however no information on the frequency of this activity was available and no fish tissue data were collected as part of this EE/CA or the earlier SI.

In general, land use in this area is limited to occasional recreational use (hiking, camping, snowmobiling), limited mining, maintenance of culverts and drainpipes, and potentially subsistence fishing.

## 3.2 Current and Potential Future Receptors

The Site is located within the Umatilla National Forest; it is not currently occupied, nor is it expected to be occupied or developed in the near future. The likely current and potential future receptors identified for the site are recreational visitors and USFS or contract maintenance workers. It is assumed that recreational visitors may include both adults and children; maintenance workers are assumed to be adult only. While ceremonial fishing may occur in this area, no fish tissue data were collected and therefore potential exposures to this receptor were not quantified as part of this HHRE.

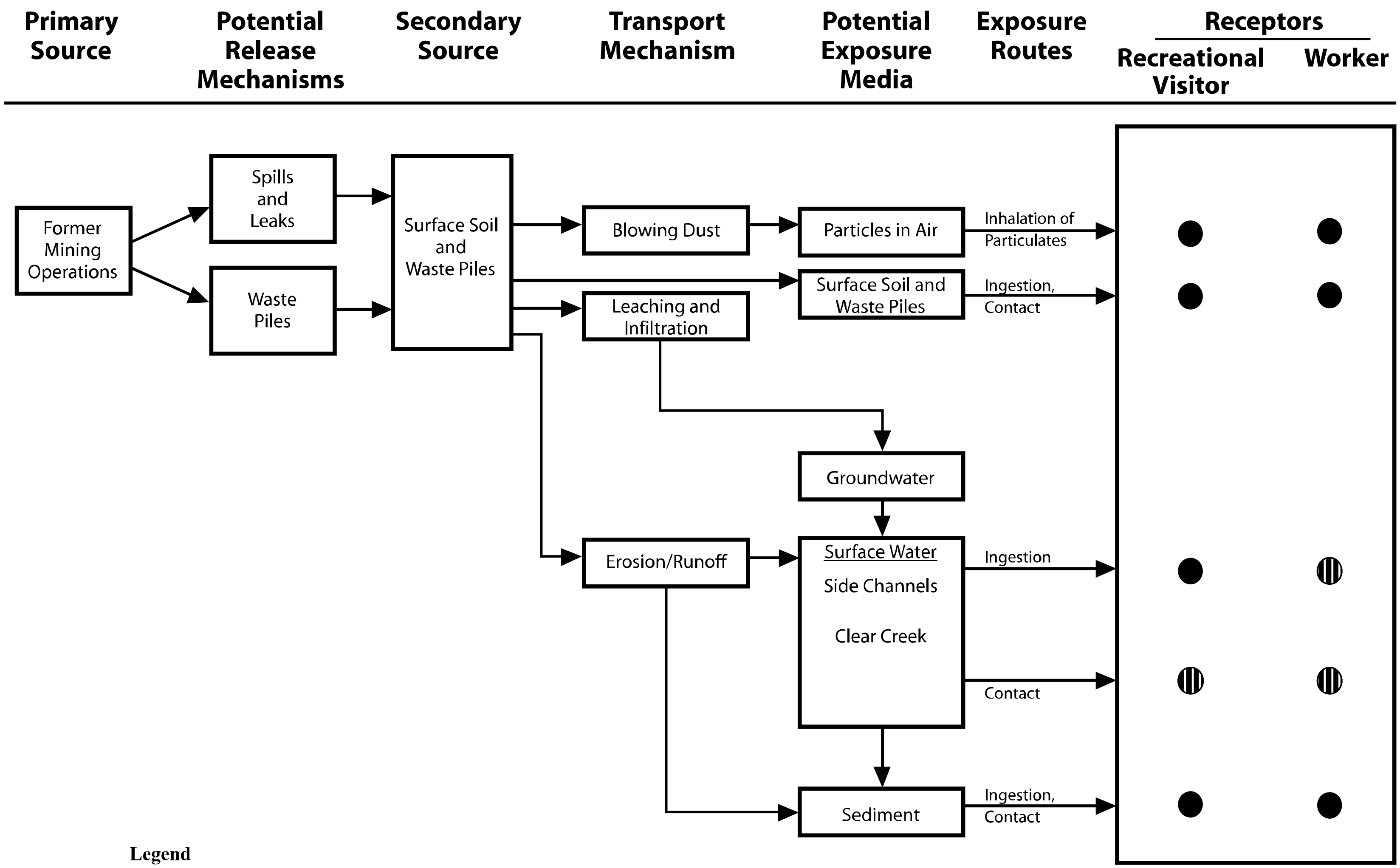
## 3.3 Identification of Potential Exposure Pathways

This section identifies potential pathways for human exposures to the COPCs. In general, an exposure pathway consists of four elements: a source of chemical release into the environment, an environmental medium for transport of the chemical (e.g., air, groundwater or soil), a point of potential human exposure (the exposure point), and a route of exposure of the chemical into the body (e.g., breathing, eating, drinking or skin contact). The conceptual site model is presented as Figure 1.

Although the risk of long-term exposure to contaminants at the site is considered low, the ingestion, dermal contact and air exposure pathways are considered complete, because recreational visitors and maintenance workers have the potential to access contaminated soil or waste, sediment, or surface water.

## 3.4 Exposure Scenarios

At the Site, a recreational visitor camping in the vicinity of the site was identified as the most conservative (i.e., health protective) scenario. Exposure to COPCs was evaluated for incidental ingestion of and dermal contact with surface soil, waste rock and sediment, inhalation of airborne particulates, and ingestion of surface water as a drinking water source. In addition, maintenance workers may be involved in maintenance at the site for two days per year (quarterly, four hours each visit); potential exposure to COPCs by a maintenance worker was also evaluated in this HHRE.




**Legend**

- ● Complete and potentially significant exposure
- ◍ Potentially Complete but insignificant exposure (not to be quantified)
- —— Potentially Pathway or Medium

**Figure 1**

**Human Health Conceptual Site Model**

**Bluebird Mine Site**

### 3.5 Exposure Assumptions

Exposure assumptions include factors such as body weight, averaging time, exposure frequency, and exposure duration. For purposes of this HHRE, initial calculations were performed using reasonable maximum exposure (RME) assumptions, which are discussed below. If the RME assumptions result in a determination that potential risks are above levels of concern, central tendency exposure (CTE) assumptions will be used to develop estimates of risk for average exposures.

Default exposure assumptions, based on USEPA and ODEQ guidance, were used when available. These include body weight, exposure duration, averaging time, soil adherence factor, skin surface area, inhalation rate, and water ingestion rate. Assumptions that do not have default values are discussed below. All exposure assumptions are presented in Attachment B, Tables B-1 through B-2.

- *Exposure Frequency:* Exposure frequency is the number of days per year that an individual participates in a particular activity. A recreational visitor was assumed to camp at the site for 7 days each year. In general, there is a 14-day camping limit on National Forest administered lands. Because (1) there are no established campgrounds near this site, (2) slopes are moderately steep and not conducive to setting up a tent, (3) most of the site is located across a creek from the road, and (4) fishing in the creek is prohibited, an assumption that a recreational visitor would camp in this location for 7 days was considered a reasonable maximum. For the maintenance worker, exposures were assumed to take place two days per year, once in the spring and once in the fall.

- *Exposure Time for Incidental Soil/Sediment Ingestion:* Based on the areal extent of contamination, it was assumed that a recreational visitor would be in contact with contaminated soil or waste rock for 2 hours each day. It was assumed that contact with sediment would occur for 1 hour each day. A maintenance worker was assumed to be in contact with soil and sediment for a standard 8-hour work day.

- Sediment ingestion rate and sediment adherence factor were assumed to be the same as for soil. The soil ingestion rate is the default ingestion rate for a residential receptor.

### 3.6 Exposure Point Concentrations

Exposure point concentrations (EPCs) represent the chemical concentrations in soil, surface water, and sediment that a receptor will potentially contact during the exposure period. The EPC is used to calculate the Intake, or Average Daily Dose (ADD) of a contaminant. Generally, the EPC is not the maximum concentration detected at the site because, in most situations, it is not reasonable to assume long-term contact with the maximum concentration. Average concentrations are used because toxicity criteria are based on lifetime average exposures, and an average concentration is most representative of the concentration contacted over time, based on the assumption that an exposed individual moves randomly across an exposure area.

Exposure to a chemical can be calculated using the EPC in units of mg/L for water, mg/kg for soils/wastes and sediment, or $mg/m^3$ for air. EPCs are combined with the exposure parameters identified in Section 3.5 above to calculate the intake, or average daily dose of a contaminant. Equations for calculating intake are presented in ODEQ 2000; intakes are presented in Attachment B.

The data for some media at the Site are limited. Risk calculations were based on 9 soil/waste samples, 11 surface water samples, and 17 sediment samples.

When data sets are small, the maximum detected concentration is used as the EPC. Average concentrations represent more realistic EPCs as they assume equal access to all portions of the site. Because the RME scenario is evaluated in this streamlined HHRE, statistical analysis and calculation of the 90 percent upper confidence level (UCL90) on the mean was used to estimate the EPC. If the UCL90 was greater than the maximum detected concentration, then the maximum detected concentration was used as the EPC.

The UCL90 is a conservative estimate of the mean concentration, and is specified in Oregon's Revised Cleanup Rules, OAR 340-122-084. It is appropriate for use when the data are normally distributed. ODEQ's spreadsheet for calculation of a one-sided 90 percent upper confidence limit of the mean was used (http://www.deq.state.or.us/wmc/tank/ucls.htm).

The EPCs used to calculate risks are presented in Table 1. One iron sample in soil/waste was excluded from the calculation of EPCs. This was a sample identified as "iron precipitate in gully," at 557,000 mg/kg. This value is almost 20 times the arithmetic mean concentration of the remaining iron data, and does not represent likely exposures at this site.

**Table 1: Exposure Point Concentrations [a]**

| *COPC* | *No. of Samples* | *Maximum Concentration* | *EPC* | *Comments* |
|---|---|---|---|---|
| Soils/Wastes (mg/kg) | | | | |
| Aluminum | 12 | 19,100 | 14,900 | Lognormal UCL90 |
| Arsenic | 12 | 165 | 65.9 | Lognormal UCL90 |
| Iron[a] | 11 | 49,800 | 36,600 | Lognormal UCL90 |
| Surface Water (mg/L) | | | | |
| Aluminum | 11 | 0.134 | 0.068 | Normal UCL90 |
| Arsenic[b] | 11 | 0.0028 | 0.0024 | Normal UCL90 |
| Iron | 11 | 0.175 | 0.083 | Lognormal UCL90 |
| Sediment (mg/kg) | | | | |
| Aluminum | 17 | 42,700 | 15,200 | Lognormal UCL90 |
| Arsenic | 17 | 55.7 | 40.4 | Lognormal UCL90 |
| Iron | 17 | 61,100 | 35,400 | Lognormal UCL90 |

EPC = Exposure Point Concentration
UCL90 = 90 percent confidence limit on the mean
[a] Excludes one sample identified as "iron precipitate in gully." This sample is evaluated in Section 6, Determination of Potential Hot Spots.
[b] Only one of 11 samples contained arsenic above the detection limit. The normal UCL90 was used to represent the exposure point concentration; however this value likely significantly overestimates the average concentration of arsenic in surface water.

## 4.0 TOXICITY ASSESSMENT

The objectives of the toxicity assessment were to evaluate the inherent toxicity of the COPCs, and to identify and select toxicity values for use in calculating human health risk. The purpose of the toxicity assessment is as follows:

- To identify the cancer and noncancer health 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.

### 4.1 Toxicity Values

Toxicity values are used to quantify the relationship between the level of exposure to a COPC and the potential increased likelihood or severity of adverse health effects. The sources used to obtain toxicity information and methods for deriving toxicity criteria are presented below.

Both cancer and noncancer health effects were evaluated quantitatively. Dose-response estimates are presented as reference doses (RfDs) for non-carcinogenic effects (those not related to cancer) and cancer slope factors (SFs) for carcinogenic effects. Some chemicals (e.g., arsenic) may exhibit both types of effects.

The following USEPA sources of toxicity values were used:

- Arsenic: Integrated Risk Information System (IRIS) (USEPA 2004a)
- Iron: National Center for Environmental Assessment, Risk Assessment Issue Paper for Derivation of a Provisional RfD for Iron (USEPA 1999a)
- Aluminum: National Center for Environmental Assessment, as cited in USEPA Region 9's PRG tables (USEPA 2004b).

### 4.2 Noncancer Health Effects

Noncancer health effects, by definition, include all adverse health impacts other than cancer. For most noncancer effects, protective mechanisms within an individual are assumed to exist that must be overcome before an adverse effect is elicited. The level above which effects may occur is referred to as a threshold level or reference dose (RfD). Examples of noncancer health effects include central nervous system disorders (e.g., neurological damage or impairment), blood disorders (e.g., anemia), organ toxicity (e.g., kidney, liver, and heart effects), reproductive toxicity (e.g., infertility), and developmental effects (e.g., birth defects, miscarriage).

Methods used by USEPA to develop toxicity values for noncancer health effects (RfDs) are described in *Risk Assessment Guidance for Superfund* (USEPA 1989). The toxicity values for the non-carcinogenic COPCs are listed in Table 2. RfD values for the oral ingestion pathway were available for all COPCs; an RfD value for the inhalation pathway was available only for aluminum.

**Table 2: Toxicity Values for Noncarcinogenic COPCs**

| COPC | Chronic RfD (mg/kg-day) | | Uncertainty Factor | | Critical Effect |
|---|---|---|---|---|---|
| | Oral | Inhalation | Oral | Inhalation | |
| Aluminum | 1.0 | 0.0014 | NA | NA | NA |
| Arsenic | 0.0003 | NA | 3 | NA | Hyperpigmentation, keratosis, and possible vascular complications |
| Iron | 0.3 | NA | 1 | NA | Chronic iron overload |

### 4.3 Carcinogenic Effects

In *Guidelines for Carcinogen Risk Assessment* (USEPA 1986), USEPA described the general framework to be followed in developing an analysis of carcinogenic risk. The Guidelines also identified principles to be used in evaluating the quality of data and in formulating judgments concerning the nature and magnitude of the cancer hazard from suspect carcinogens. The general theory behind cancer development and the process used by USEPA to classify chemicals as carcinogens are described in *Risk Assessment Guidance for Superfund* (USEPA 1989). The derivation of a dose-response relationship for potential and known carcinogens (called a slope factor) is described in USEPA 1989 and the *Proposed Guidelines for Carcinogen Risk Assessment* (USEPA 1996) and *Guidelines for Carcinogen Risk Assessment* (Review Draft; USEPA 1999b).

Arsenic is the only carcinogenic COPC at the Site. Slope factors for arsenic, in units of $(mg/kg\text{-}day)^{-1}$, are presented in Table 3.

**Table 3: Toxicity Values for Carcinogenic COPCs**

| COPC | Oral SF $(mg/kg\text{-}day)^{-1}$ | Type of Cancer | Weight of Evidence | Source | Inhalation SF $(mg/kg\text{-}day)^{-1}$ | Type of Cancer | Weight of Evidence | Source |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 1.5E+00 | Skin | A | IRIS | 15 | Lung | A | IRIS |

### 4.4 Toxicity Summaries

The toxic effects of the COPCs are briefly summarized in the following subsections.

#### *4.4.1 Arsenic*

Arsenic is a COPC in soils/wastes, surface water, and sediments at the Site. Arsenic occurs in soil and rock along with other minerals such as copper, lead, iron, and nickel. It is typically found in soil in the form of an insoluble sulfide. Naturally-occurring arsenic concentrations in soil range from 1 to 40 mg/kg, with a mean concentration of approximately 5 mg/kg. The maximum concentration limit (MCL) for arsenic in drinking water is 10 µg/L.

Inorganic arsenic (the form typically found in soil or water) is often in a form that is readily absorbed by ingestion. Following absorption, it is distributed throughout the body. Studies with laboratory animals suggest that the bioavailability of arsenic in soil may be lower than that of arsenic ingested in solution. The issue of arsenic bioavailability is especially important at mining, milling, and smelting sites because the arsenic at these sites often exists, at least in part, as a poorly soluble sulfide and may also occur in particles of inert or insoluble material. These factors all tend to reduce the bioavailability of arsenic.

The distinguishing adverse effects associated with chronic ingestion of arsenic are skin lesions (hyperkeratosis and hyperpigmentation) and skin cancer. Other adverse effects due to ingestion exposure include cancer of internal organs. USEPA has given arsenic a carcinogenicity weight-of-evidence classification of Group A (human carcinogen) based on sufficient evidence of cancer mortality from both ingestion and inhalation exposures in human populations. The International Agency for Research on Cancer classifies arsenic as a proven human carcinogen.

The oral reference dose (RfD) is based on the occurrence of hyperpigmentation and hyperkeratosis, and vascular complications observed in a human population ingesting elevated levels of arsenic in drinking water. The oral RfD for arsenic is 0.0003 mg/kg per day (used in this risk evaluation), although strong scientific arguments can be made to adjust this RfD between 0.0001 to 0.0008 mg/kg per day (USEPA 2004c). The oral unit risk factor for estimating excess lifetime cancer risks is based on the incidence of skin cancer observed in a human population ingesting elevated levels of arsenic in drinking water.

### *4.4.2 Iron*

Iron is a COPC in soils/wastes at the Site. Iron is a major constituent in rocks and soil generally at concentrations averaging about 2 percent (20,000 mg/kg). Iron is an essential element in human nutrition; however, there is the potential for adverse health effects from excessive ingestion.

Iron bioavailability is important when considering sediment or soil exposure pathways because iron in sediment can exist, at least in part, as poorly soluble salts and may also occur in particles of inert or insoluble material. These factors all tend to reduce the bioavailability of iron.

Chronic overexposure (also known as iron overload) may occur as a result of excessive dietary consumption of iron with accumulation in the liver, spleen, pancreas, endocrine organs, and the heart. Adverse effects may include disturbance of liver function, diabetes mellitus, disturbance of endocrine function, and cardiovascular effects. Elevated exposure to iron is not considered to be associated with reproductive or developmental toxicity.

USEPA's IRIS database does not currently provide a reference dose, cancer slope factor, or other toxicological information for iron (USEPA 2004c). The USEPA Superfund Technical Support Center has developed a provisional oral RfD for iron. USEPA notes that iron is an essential element and that deriving a risk assessment value for it poses special problems. The provisional chronic oral RfD is 0.3 mg/kg per day. An uncertainty factor of 1 is supported by the fact that iron is an essential element. This RfD may not be protective of individuals with inherited disorders of iron metabolism and could be conservative if applied to exposure scenarios involving forms of iron with low bioavailability.

### *4.4.3 Aluminum*

Aluminum is a COPC in sediment at the Site. It makes up about 8 percent of the earth's crust. Until recently, aluminum has existed in forms not available to humans and most other species. However, acid rain has increased the availability of aluminum to biological systems and has resulted in destructive effects on fish and plant species. It is unknown if humans are susceptible to this increased bioavailability. It is poorly absorbed and efficiently eliminated; however, when absorption does occur, aluminum is distributed mainly in bone, liver, testes, kidneys, and brain. Aluminum may be involved in Alzheimer's disease.

The respiratory system appears to be the primary target following inhalation exposure to aluminum. Aluminum has been placed in the USEPA weight-of-evidence classification D, not classifiable as to human carcinogenicity. The National Center for Environmental Assessment (NCEA) has established a provisional oral RfD of 1.0 mg/kg per day, and an inhalation RfD of 1.4E-3 mg/kg per day.

## 5.0 RISK CHARACTERIZATION

Risk characterization integrates the results of the exposure and toxicity assessments by combining estimates of chemical intake (Section 3.0) with toxicity data (Section 4.0) to determine the likelihood of adverse effects to potentially exposed populations. Risk characterization also serves as the bridge between risk assessment and risk management and is a key step in the ultimate decision-making process (USEPA 1989). Because of the fundamental differences in the mechanisms through which carcinogenic and noncarcinogenic processes occur, risks are characterized separately for these two types of heath effects. This section presents risks for each complete exposure pathway identified during the exposure assessment.

### 5.1 Noncancer Hazard Quotients

The potential for noncancer health effects was evaluated by comparing the intake of a chemical with the reference dose. The resulting ratio is the hazard quotient (HQ), which is calculated using the following equation:

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

Where:

Intake = Average daily intake of a chemical (mg/kg per day)
RfD = Reference dose (mg/kg per day)

An HQ is not a mathematical prediction of the incidence or severity of effects (i.e., probability), but is instead a numerical index (i.e., a ratio) that can be used to determine if the estimated exposure may present a potential health threat (USEPA 1989). When the daily intake of a chemical exceeds the reference dose (i.e., HQ greater than 1) there is a potential for noncancer health effects.

Noncancer hazards resulting from exposure to multiple chemicals are estimated through the calculation of a hazard index (HI). An HI is a summation of relevant HQ values and is used to determine if an exposed individual is at risk of developing adverse health effects resulting from simultaneous exposure to all selected chemicals by all complete exposure pathways. Risks from exposure to multiple chemicals are assumed to be additive; this does not address potential synergistic or antagonistic interactions.

An HI greater than 1 suggests that simultaneous exposure to all chemicals may present a potential health threat. The level of concern increases as the HI approaches and exceeds a value of 1. HI results greater than 1 should be interpreted cautiously because (1) slopes of chemical-specific dose-response curves may differ substantially, and the respective HQs may not be directly comparable among different chemicals; and (2) the RfDs have varying degrees of confidence associated with them because of the relative strength of the toxicity database for each chemical and the range of uncertainty and modifying factors used in developing the RfD. Under these circumstances (HI greater than 1), USEPA recommends segregating the compounds into groups of like or common toxicological effects and reevaluating the potential for manifestation of the various adverse health effects identified (USEPA 1989).

## 5.2 Cancer Risks

Potential health risk associated with carcinogens was estimated by calculating the increased probability of an individual developing cancer during his or her lifetime as a result of exposure to a carcinogenic compound. These excess lifetime cancer risks were computed using the estimated chemical intakes calculated in the exposure assessment (Section 3.0) and the cancer slope factors (SFs) identified in the toxicity assessment (Section 4.0). Arsenic is the only carcinogenic COPC that was identified for the Blackbird Mine site.

When calculating cancer risk it can be assumed that the dose-response relationship will be in the linear portion of the dose-response curve according to the following equation:

$$\textit{Cancer Risk} = \textit{Intake} \times \textit{CSF}$$

Where:

| | | |
|---|---|---|
| Cancer risk | = | A unitless probability of an individual developing cancer |
| Intake | = | Chemical intake (mg/kg per day) |
| CSF | = | Cancer slope factor $(\text{mg/kg per day})^{-1}$ |

Resulting cancer risks represent the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. Because the SFs are typically the 95th percentile of the probability of a carcinogenic response, the resulting carcinogenic risk estimate is also an upper bound determination. In other words, the true risk is not likely to exceed the estimated risk and is in fact likely to be less. Because 95 percentiles are not truly additive, the total cancer risk may become artificially more conservative as risks from a number of different carcinogens are combined. Thus the total cancer risk may be overestimated because of the combination of conservative estimates of cancer potency used to calculate risk.

## 5.3 Risk and Hazard Estimates for the Recreational Visitor

Table 4 summarizes the quantitative risk results for the recreational visitor. Calculations, assumptions, and inputs are presented in Attachment B.

Table 4: Risk Results -- Recreational Visitor (RME Scenario)

| *COPC* | *Excess Cancer Risk* | *Hazard Index* |
|---|---|---|
| Aluminum | NA | 0.0007 |
| Arsenic | 2E-6 | 0.03 |
| Iron | NA | 0.005 |
| Total | 2E-6 | 0.04 |

Risks are discussed below.

- Soils/Wastes and Sediment: Cancer risks to a recreational visitor from arsenic in soils, waste materials, and sediment are below 1E-6. Noncancer hazards are less than 1.

- Surface Water: The cancer risk due to the presence of arsenic in surface water slightly exceeds the acceptable risk level for a single chemical of 1E-6. It should be noted that arsenic was detected in only one of 11 surface water samples, and the EPC of 2.4 µg/L is likely to substantially overestimate the mean concentration. In addition, the drinking water Maximum Contaminant Level (MCL) for arsenic is 10 µg/L, which is significantly higher than the concentration of arsenic in Clear Creek. Therefore, arsenic in surface water is not believed to pose an unacceptable risk to recreational visitors.

### 5.4 Risk and Hazard Estimates for the Maintenance Worker

Table 5-2 summarizes the quantitative risk results for the maintenance worker. Calculations, assumptions, and inputs are presented in Attachment B.

**Table 5: Risk Results -- Maintenance Worker (RME Scenario)**

| *COPC* | *Excess Cancer Risk* | *Hazard Index* |
|---|---|---|
| Aluminum | NA | 0.00008 |
| Arsenic | 2E-7 | 0.001 |
| Iron | NA | 0.0006 |
| Total | 2E-7 | 0.002 |

Cancer risks and noncancer hazards to maintenance workers do not exceed levels of concern for any of the exposure pathways evaluated.

## 6.0 DETERMINATION OF POTENTIAL HOT SPOTS

An assessment of hot spots is performed by comparing the concentration of a site contaminant to its “highly concentrated” hot spot level, defined as the concentration corresponding to a lifetime cancer risk of 1E-4 for carcinogens and a hazard quotient of 10 for noncarcinogens.

No contaminants were present at levels above their “highly concentrated” hot spot level.

## 7.0 SUMMARY OF RISKS

Of the 23 COIs detected at the Site, only aluminum, arsenic, and iron were identified as COPCs. Exposure to these three chemicals was evaluated quantitatively in this HHRE. Based on current and projected future land use, individuals who may come in contact with site-related contaminants during recreational activities such as camping and hiking were identified as potential receptors. In addition, USFS employees or contract workers involved in maintenance of culverts and drain pipes were also identified as potential receptors. Results of the HHRE indicate that the potential for carcinogenic and non-carcinogenic human health impacts resulting from exposure to site contaminants is low. With the exception of a single surface water sample, concentrations of constituents in soils, waste rock, surface water, and sediment did not exceed the regulatory standards, and therefore risk-based cleanup goals were not calculated. Arsenic was detected in surface water in only one of 11 samples, at an estimated concentration of 2.8 µg/L, which is below the drinking water MCL of 10 µg/L.

## 8.0 REFERENCES

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**Attachment A: COPC Screening**
**Streamlined Human Health Risk Evaluation**
**Bluebird Mine Site**

**Table A-1: Bluebird Mine -- Soils/Wastes Prescreening**

| Chemical | Minimum Detected Conc'n | Maximum Detected Conc'n | Units | Detection Frequency (%) | Retained for Screening? | Background Conc'n | Retained for Screening? |
|---|---|---|---|---|---|---|---|
| Aluminum | 1,970 | 19,100 | mg/kg | 100% | yes | 27,500 | no |
| **Antimony** | 0.82 | 45.5 | mg/kg | 100% | yes | 1.2 | **yes** |
| **Arsenic** | 7.3 | 165 | mg/kg | 100% | yes | 8.1 | **yes** |
| Barium | 22.6 | 271 | mg/kg | 100% | yes | 430 | no |
| Beryllium | 0.12 | 0.63 | mg/kg | 100% | yes | 0.94 | no |
| **Cadmium** | <0.023 | 3 | mg/kg | 31% | yes | 0.16 | **yes** |
| **Calcium** | <18.1 | 4,040 | mg/kg | 77% | yes | 1,880 | **yes** |
| **Chromium (total)** | 8.6 | 147 | mg/kg | 100% | yes | 12.5 | **yes** |
| **Chromium (VI)** | 0.76 | 4.9 | mg/kg | 100% | yes | <2.1 | **yes** |
| **Cobalt** | 3.5 | 31.4 | mg/kg | 100% | yes | 12.9 | **yes** |
| **Copper** | 37 | 95.3 | mg/kg | 100% | yes | 52.6 | **yes** |
| **Iron** | 15,300 | 557,000 | mg/kg | 100% | yes | 35,300 | **yes** |
| **Lead** | 3.8 | 157 | mg/kg | 100% | yes | 8.2 | **yes** |
| **Magnesium** | 573 | 17,500 | mg/kg | 100% | yes | 1,910 | **yes** |
| **Manganese** | 72.5 | 8,270 | mg/kg | 100% | yes | 1,502 | **yes** |
| **Mercury (total)** | 0.035 | 82 | mg/kg | 100% | yes | 0.068 | **yes** |
| **Nickel** | 7.2 | 221 | mg/kg | 100% | yes | 39.5 | **yes** |
| **Potassium** | 327 | 3,370 | mg/kg | 100% | yes | 1,450 | **yes** |
| **Selenium** | 1.3 | 25.7 | mg/kg | 100% | yes | 1.9 | **yes** |
| **Silver** | 0.1 | 53.4 | mg/kg | 100% | yes | 0.53 | **yes** |
| **Sodium** | <31.4 | 679 | mg/kg | 92% | yes | 358 | **yes** |
| **Thallium** | 0.88 | 30.9 | mg/kg | 100% | yes | 1.5 | **yes** |
| **Vanadium** | 3.8 | 93.3 | mg/kg | 100% | yes | 38.5 | **yes** |
| **Zinc** | 46 | 165 | mg/kg | 100% | yes | 102 | **yes** |

mg/kg = milligrams of chemical per kilogram of soil

## Table A-2: Bluebird Mine -- Surface Water Prescreening

| Chemical | Minimum Detected Conc'n | Maximum Detected Conc'n | Units | Detection Frequency (%) | Retained for Screening? | Background Conc'n | Retained for Screening? |
|---|---|---|---|---|---|---|---|
| **Aluminum** | <23.6 | 34 | ug/L | 82% | **yes** | <23.6 | **yes** |
| **Antimony** | <4.7 | 6 | ug/L | 36% | **yes** | <4.7 | **yes** |
| **Arsenic** | <2.4 | 2.8 | ug/L | 9% | **yes** | <4.8 | **yes** |
| **Barium** | 14 | 17.9 | ug/L | 100% | **yes** | 15.4 | **yes** |
| **Beryllium** | 0.2 | 0.32 | ug/L | 27% | **yes** | <0.2 | **yes** |
| Cadmium | <0.6 | <0.6 | ug/L | 0% | no | -- | |
| **Calcium** | 11,900 | 13,400 | ug/L | 100% | **yes** | 12,60 | **yes** |
| Chromium (total) | <1.4 | 1.9 | ug/L | 27% | **yes** | 2.7 | no |
| Cobalt | <1.8 | <2 | ug/L | 0% | no | -- | |
| Copper | <2.4 | <2.4 | ug/L | 0% | no | -- | |
| Cyanide | <0.01 | <10 | ug/L | 0% | no | -- | |
| **Iron** | <33.3 | 175 | ug/L | 91% | **yes** | 69 | **yes** |
| Lead | <1.3 | <1.5 | ug/L | 0% | no | -- | |
| **Magnesium** | 6,500 | 7,720 | ug/L | 100% | **yes** | 7,620 | **yes** |
| **Manganese** | 4.2J | 13.8 | ug/L | 100% | **yes** | 5 | **yes** |
| **Mercury (total)** | <0.1 | 0.11 | ug/L | 9% | **yes** | <0.1 | **yes** |
| Nickel | <2 | <2.1 | ug/L | 0% | no | -- | |
| **Potassium** | 1,100 | 1,360 | ug/L | 100% | **yes** | 1,210 | **yes** |
| **Selenium** | <1.7 | 4.5 | ug/L | 9% | **yes** | <3.4 | **yes** |
| Silver | <0.9 | <2.2 | ug/L | 0% | no | -- | |
| **Sodium** | 2,490 | 3,040 | ug/L | 100% | **yes** | 2,680 | **yes** |
| Thallium | <2.8 | <5.7 | ug/L | 0% | no | -- | |
| **Vanadium** | <2 | 2.5 | ug/L | 27% | **yes** | <2 | **yes** |
| Zinc | 2.4 J | <5.7 | ug/L | 64% | **yes** | 4.2 | no |

ug/L = micrograms of chemical per liter of water

**Table A-3: Bluebird Mine -- Sediment Prescreening**

| Chemical | Minimum Detected Conc'n | Maximum Detected Conc'n | Units | Detection Frequency (%) | Retained for Screening? | Background Conc'n | Retained for Screening? |
|---|---|---|---|---|---|---|---|
| **Aluminum** | 6,680 | 42,700 | mg/kg | 100% | yes | 15,870 | **yes** |
| **Antimony** | <0.47 | 5.9 | mg/kg | 88% | yes | 2.9 | **yes** |
| **Arsenic** | 3.9 | 55.7 | mg/kg | 100% | yes | 35.3 | **yes** |
| **Barium** | 40.5 | 405 | mg/kg | 100% | yes | 74.4 | **yes** |
| **Beryllium** | 0.11 | 1.2 | mg/kg | 100% | yes | 0.35 | **yes** |
| **Cadmium** | <0.059 | 4.2 | mg/kg | 59% | yes | 0.49 | **yes** |
| **Calcium** | 1,070 | 6,750 | mg/kg | 100% | yes | 3,120 | **yes** |
| **Chromium (total)** | 10.7 | 191 | mg/kg | 100% | yes | 116 | **yes** |
| **Cobalt** | 9.5 | 85.5 | mg/kg | 100% | yes | 24.6 | **yes** |
| **Copper** | 17.7 | 323 | mg/kg | 100% | yes | 30.8 | **yes** |
| Cyanide | <0.61 | <0.61 | mg/kg | 0% | no | -- | |
| **Iron** | 14,000 | 61,100 | mg/kg | 100% | yes | 34,400 | **yes** |
| **Lead** | 1.3 | 11.6 | mg/kg | 100% | yes | 3.5 | **yes** |
| **Magnesium** | 2,690 | 21,500 | mg/kg | 100% | yes | 11,120 | **yes** |
| **Manganese** | 409 | 3,090 | mg/kg | 100% | yes | 797 | **yes** |
| **Mercury (total)** | <0.019 | 0.38 | mg/kg | 53% | yes | 0.026 | **yes** |
| **Nickel** | 51.9 | 503 | mg/kg | 100% | yes | 158 | **yes** |
| **Potassium** | 350 | 2,650 | mg/kg | 100% | yes | 1,070 | **yes** |
| **Selenium** | <0.17 | 2.9 | mg/kg | 76% | yes | 0.66 | **yes** |
| **Silver** | <0.22 | 2.6 | mg/kg | 12% | yes | <0.27 | **yes** |
| **Sodium** | 62.3 | 1,040 | mg/kg | 100% | yes | 319 | **yes** |
| **Thallium** | <0.58 | 2.4 | mg/kg | 53% | yes | 1.62 | **yes** |
| **Vanadium** | 10.6 | 106 | mg/kg | 100% | yes | 64 | **yes** |
| **Zinc** | 28.8 | 556 | mg/kg | 100% | yes | 72.3 | **yes** |

mg/kg = milligrams of chemical per kilogram of sediment

## Table A-4: Bluebird Mine -- PRG Screening, Soils/Wastes

| Chemical | Cancer/ Noncancer | Maximum Detected Concentration (mg/kg) | USEPA Region 9 PRG Indust. Soil (mg/kg) | Individual COI Risk Ratio, Ri | Individual COPC? | Multiple COIs Ri/Rtotal | 1/N | Multiple COPC - Soils/Wastes? |
|---|---|---|---|---|---|---|---|---|
| Antimony | nc | 45.5 | 410 | 0.11 | no | 0.0010 | 0.059 | no |
| **Arsenic** | ca/nc | 165 | 1.6 | 103 | **yes** | 0.93 | 0.059 | **yes** |
| Cadmium | nc | 3 | 450 | 0.0067 | no | 0.000060 | 0.059 | no |
| Calcium(a) | NA | 4,040 | NA | NA | no | NA | | no |
| Chromium (total) | ca | 147 | 450 | 0.33 | no | 0.0030 | 0.059 | no |
| Chromium (VI) | ca | 4.9 | 64 | 0.077 | no | 0.00069 | 0.059 | no |
| Cobalt | ca | 31.4 | 1,900 | 0.017 | no | 0.00015 | 0.059 | no |
| Copper | nc | 95.3 | 41,000 | 0.0023 | no | 0.000021 | 0.059 | no |
| **Iron** | nc | 557,000 | 100,000 | 5.6 | **yes** | 0.050 | 0.059 | no |
| Lead | nc | 157 | 800 | 0.20 | no | 0.0018 | 0.059 | no |
| Magnesium(a) | NA | 17,500 | NA | NA | no | NA | | no |
| Manganese | nc | 8,270 | 19,000 | 0.44 | no | 0.0039 | 0.059 | no |
| Mercury (total) | nc | 82 | 310 | 0.26 | no | 0.0024 | 0.059 | no |
| Nickel | nc | 221 | 20,000 | 0.011 | no | 0.00010 | 0.059 | no |
| Potassium(a) | NA | 3,370 | NA | NA | no | NA | | no |
| Selenium | nc | 25.7 | 5,100 | 0.0050 | no | 0.000046 | 0.059 | no |
| Silver | nc | 53.4 | 5,100 | 0.010 | no | 0.000095 | 0.059 | no |
| Sodium(a) | NA | 679 | NA | NA | no | NA | | no |
| Thallium | nc | 30.9 | 67 | 0.46 | no | 0.0042 | 0.059 | no |
| Vanadium | nc | 93.3 | 1,000 | 0.093 | no | 0.00084 | 0.059 | no |
| Zinc | nc | 165 | 100,000 | 0.0017 | no | 0.000015 | 0.059 | no |

| | |
|---|---|
| **Sum of Risk Ratios (Rtotal)** | **110.71** |
| **Number of COIs (N)** | **17** |
| **1/N** | **0.059** |

(a) Essential nutrients (calcium, magnesium, potassium, sodium) were not retained as COPCs per EPA guidance (USEPA 1989)

NA = Not applicable
COI = Chemical of interest
ca = carcinogen
nc = noncarcinogen
PRG = Preliminary Remediation Goal

## Table A-5: Bluebird Mine -- PRG Screening, Surface Water

| Chemical | Cancer/ Noncancer | Maximum Detected Concentration (ug/L) | USEPA Region 9 PRG Tap Water (ug/L) | Individual COI Risk Ratio, Rsw | Individual COPC - Surface Water? | Multiple COIs Rsw/Rtotal | 1/N | Multiple COPC - Surface Water? |
|---|---|---|---|---|---|---|---|---|
| Aluminum | nc | 34 | 36,000 | 0.00094 | no | 0.000015 | 0.10 | no |
| Antimony | nc | 6 | 15 | 0.40 | no | 0.0064 | 0.10 | no |
| **Arsenic** | ca/nc | 2.8 | 0.045 | 62 | **yes** | 0.99 | 0.10 | **yes** |
| Barium | nc | 17.9 | 2,600 | 0.0069 | no | 0.00011 | 0.10 | no |
| Beryllium | nc | 0.32 | 73 | 0.0044 | no | 0.000070 | 0.10 | no |
| Calcium(a) | NA | 13,400 | NA | NA | no | NA | | no |
| Iron | nc | 175 | 1,100 | 0.16 | no | 0.0025 | 0.10 | no |
| Magnesium(a) | NA | 7,720 | NA | NA | no | NA | | no |
| Manganese | nc | 13.8 | 880 | 0.016 | no | 0.00025 | 0.10 | no |
| Mercury (total) | nc | 0.11 | 11 | 0.010 | no | 0.00016 | 0.10 | no |
| Potassium(a) | NA | 1,360 | NA | NA | no | NA | | no |
| Selenium | nc | 4.5 | 180 | 0.025 | no | 0.00040 | 0.10 | no |
| Sodium(a) | NA | 3,040 | NA | NA | no | NA | | no |
| Vanadium | nc | 2.5 | 36 | 0.069 | no | 0.0011 | 0.10 | no |

| | |
|---|---|
| **Sum of Risk Ratios (Rwtotal)** | **62.91** |
| **Number of COIs (N)** | **10** |
| **1/N** | **0.10** |

(a) Essential nutrients (calcium, magnesium, potassium, sodium) were not retained as COPCs per EPA guidance (USEPA 1989)

NA = Not applicable
COI = Chemical of interest
ca = carcinogen
nc = noncarcinogen
PRG = Preliminary Remediation Goal

**Table A-6: Bluebird Mine -- PRG Screening, Sediment**

| Chemical | Cancer/ Noncancer | Maximum Detected Concentration (mg/kg) | USEPA Region 9 PRG Industrial Soil (mg/kg) | Individual COI Risk Ratio, Rsed | Individual COPC - Sediment? | Multiple COIs Rsed/Rtotal | 1/N | Multiple COPC - Sediment? |
|---|---|---|---|---|---|---|---|---|
| **Aluminum** | nc | 42,700 | 10,000 | 4.27 | **yes** | 0.11 | 0.053 | **yes** |
| Antimony | nc | 5.9 | 410 | 0.014 | no | 0.00035 | 0.053 | no |
| **Arsenic** | ca/nc | 55.7 | 1.6 | 34.81 | **yes** | 0.86 | 0.053 | **yes** |
| Barium | nc | 405 | 67,000 | 0.0060 | no | 0.00015 | 0.053 | no |
| Beryllium | ca/nc | 1.2 | 1,900 | 0.00063 | no | 0.000016 | 0.053 | no |
| Cadmium | nc | 4.2 | 450 | 0.0093 | no | 0.00023 | 0.053 | no |
| Calcium(a) | NA | 6,750 | NA | NA | no | NA | | no |
| Chromium (total) | ca | 191 | 450 | 0.42 | no | 0.010 | 0.053 | no |
| Cobalt | ca | 85.5 | 1900 | 0.045 | no | 0.0011 | 0.053 | no |
| Copper | nc | 323 | 41,000 | 0.0079 | no | 0.00019 | 0.053 | no |
| Iron | nc | 61,100 | 100,000 | 0.61 | no | 0.015 | 0.053 | no |
| Lead | nc | 11.6 | 800 | 0.015 | no | 0.00036 | 0.053 | no |
| Magnesium(a) | NA | 21,500 | NA | NA | no | NA | | no |
| Manganese | nc | 3,090 | 19,000 | 0.16 | no | 0.0040 | 0.053 | no |
| Mercury (total) | nc | 0.38 | 310 | 0.0012 | no | 0.000030 | 0.053 | no |
| Nickel | nc | 503 | 20,000 | 0.025 | no | 0.00062 | 0.053 | no |
| Potassium(a) | NA | 2,650 | NA | NA | no | NA | | no |
| Selenium | nc | 2.9 | 5,100 | 0.00057 | no | 0.000014 | 0.053 | no |
| Silver | nc | 2.6 | 5,100 | 0.00051 | no | 0.000013 | 0.053 | no |
| Sodium(a) | NA | 1,040 | NA | NA | no | NA | 0.053 | no |
| Thallium | nc | 2.4 | 67 | 0.036 | no | 0.00088 | | no |
| Vanadium | nc | 106 | 1,000 | 0.11 | no | 0.0026 | 0.053 | no |
| Zinc | nc | 556 | 100,000 | 0.0056 | no | 0.00014 | 0.053 | no |

| | |
|---|---|
| **Sum of Risk Ratios (Rtotal)** | **40.55** |
| **Number of COIs (N)** | **19** |
| **1/N** | **0.053** |

(a) Essential nutrients (calcium, magnesium, potassium, sodium) were not retained as COPCs per EPA guidance (USEPA 1989)

NA = Not applicable
COI = Chemical of interest
ca = carcinogen
nc = noncarcinogen
PRG = Preliminary Remediation Goal

**Table A-7: Bluebird Mine -- PRG Screening, Sum of All Media**

| Chemical | Ri (soils/wastes) | Rsw (surface water) | Rsed (sediment) | Rall (sum of all media) | Mulitple Medium COPC? |
|---|---|---|---|---|---|
| **Aluminum** | NA | 0.0016 | 4.27 | 4.27 | **yes** |
| Antimony | 0.110 | 0.40 | 0.014 | 0.52 | no |
| **Arsenic** | 103 | 62 | 34.8 | 200 | **yes** |
| Barium | NA | 0.0069 | 0.0060 | 0.013 | no |
| Beryllium | NA | 0.0044 | 0.00063 | 0.0050 | no |
| Cadmium | 0.0067 | NA | 0.0093 | 0.016 | no |
| Calcium | NA | NA | NA | NA | no |
| Chromium (total) | 0.33 | NA | 0.42 | 0.75 | no |
| Chromium (VI) | 0.077 | NA | NA | 0.077 | no |
| Cobalt | 0.017 | NA | 0.045 | 0.062 | no |
| Copper | 0.0023 | NA | 0.0079 | 0.010 | no |
| **Iron** | 5.6 | 0.16 | 0.61 | 6.4 | **yes** |
| Lead | 0.20 | NA | 0.015 | 0.21 | no |
| Magnesium | NA | NA | NA | NA | no |
| Manganese | 0.44 | 0.016 | 0.16 | 0.62 | no |
| Mercury (total) | 0.26 | 0.010 | 0.0012 | 0.27 | no |
| Nickel | 0.011 | NA | 0.025 | 0.036 | no |
| Potassium | NA | NA | NA | NA | no |
| Selenium | 0.0050 | 0.025 | 0.00057 | 0.031 | no |
| Silver | 0.010 | NA | 0.00051 | 0.011 | no |
| Sodium | NA | NA | NA | NA | no |
| Thallium | 0.46 | NA | 0.036 | 0.50 | no |
| Vanadium | 0.093 | 0.069 | 0.11 | 0.27 | no |
| Zinc | 0.0017 | NA | 0.0056 | 0.0073 | no |

**Table A-8: Bluebird Mine -- Chemicals of Potential Concern (COPCs)**

| Chemical | Soils/Wastes | | Surface Water | | Sediment | | Multiple Medium |
|---|---|---|---|---|---|---|---|
| | Individual | Multi-Chemical | Individual | Multi-Chemical | Individual | Multi-Chemical | |
| **Aluminum** | | | | | ● | ● | ● |
| Antimony | | | | | | | |
| **Arsenic** | ● | ● | ● | ● | ● | ● | ● |
| Barium | | | | | | | |
| Beryllium | | | | | | | |
| Cadmium | | | | | | | |
| Calcium | | | | | | | |
| Chromium (total) | | | | | | | |
| Chromium (VI) | | | | | | | |
| Cobalt | | | | | | | |
| Copper | | | | | | | |
| **Iron** | ● | | | | | | ● |
| Lead | | | | | | | |
| Magnesium | | | | | | | |
| Manganese | | | | | | | |
| Mercury (total) | | | | | | | |
| Nickel | | | | | | | |
| Potassium | | | | | | | |
| Selenium | | | | | | | |
| Silver | | | | | | | |
| Sodium | | | | | | | |
| Thallium | | | | | | | |
| Vanadium | | | | | | | |
| Zinc | | | | | | | |

Note: Iron is identified as a multiple medium COPC because it was detected in several media (soil/waste, surface water, and sediment), and its Rall value (see Table 7) exceeds 1. This is consistent with Oregon guidance (ODEQ 2000).

**Attachment B: Risk Calculations**
**Streamlined Human Health Risk Evaluation**
**Bluebird Mine Site**

**Table B-1. RME Exposure Factors for Recreational Visitor (Camper)**

| Exposure Parameter | Units | Adult | Child | Source |
|---|---|---|---|---|
| **General Parameters** | | | | |
| Body Weight (BW) | kg | 70 | 15 | ODEQ 2000; default value |
| Exposure Duration (ED) | years | 24 | 6 | ODEQ 2000; default values for residential exposure. Total exposure duration (adult + child) = 30 years. |
| Exposure Frequency (EF) | days/year | 7 | 7 | Professional judgement; camping stay limit in National Forest is 14 days, but due to the general unsuitability of this site for extending camping, this was multiplied by 0.5. |
| Conversion Factor 1 (CF1) | kg/mg | 1.00E-06 | 1.00E-06 | |
| Conversion Factor 2 (CF2) | hrs/day | 24 | 24 | |
| Averaging Time -- Cancer (ATc) | days | 25550 | 25550 | ODEQ 2000; default value |
| Averaging Time -- Noncancer | days | 365*ED | 365*ED | ODEQ 2000; default value |
| **Exposures to Soil** | | | | |
| Soil Ingestion Rate (IRs) | mg/day | 100 | 200 | USEPA 1991; default residential values |
| Exposure Time for Soil (ETs) | hrs/day | 2 | 2 | Professional judgement; based on areal extent of contamination |
| Soil Adherence Factor (AF) | mg/cm2-day | 0.07 | 0.2 | USEPA 2004c; default value |
| Skin Surface Area for Soil Exposure | cm2 | 5,700 | 2,800 | USEPA 2004c; default value |
| Inhalation Rate of Air (IRA) | m3/day | 15.2 | 8.3 | ODEQ 2000; default value |
| Particulate Emission Factor (PEF) | m3/kg | 1.32E+09 | 1.32E+09 | ODEQ 2000; default value |
| **Exposures to Sediment** | | | | |
| Sediment Ingestion Rate (IRsed) | mg/day | 100 | 200 | USEPA 1991; default soil ingestion rate |
| Exposure Time for Sediment (ETsed) | hrs/day | 1 | 1 | Assumes one hour spent in contact with Clear Creek water/sediments each day of camping. |
| Sediment Adherence Factor (AFsed) | mg/cm2-day | 0.07 | 0.2 | USEPA 2004c; default value |
| Skin Surface Area for Sediment Exposure | cm2 | 5,700 | 2,800 | USEPA 2004c; default value |
| **Exposures to Surface Water** | | | | |
| Water Ingestion Rate (IRw) | L/day | 2.3 | 1.5 | ODEQ 2000; default values for tap water ingestion |

## Table B-2. RME Exposure Factors for Maintenance Worker

| Exposure Parameter | Units | Adult | Source |
|---|---|---|---|
| **General Parameters** | | | |
| Body Weight (BW) | kg | 70 | ODEQ 2000; default value |
| Exposure Duration (ED) | years | 25 | ODEQ 2000; default value for occupational exposure. |
| Exposure Frequency (EF) | days/year | 2 | Assumes 1 day each in spring and fall for maintenance of culverts and discharge pipes. |
| Conversion Factor 1 (CF1) | kg/mg | 1.00E-06 | |
| Conversion Factor 2 (CF2) | hrs/day | 24 | |
| Averaging Time -- Cancer (ATc) | days | 25550 | ODEQ 2000; default value |
| Averaging Time -- Noncancer | days | 365*ED | ODEQ 2000; default value |
| **Exposures to Soil** | | | |
| Soil Ingestion Rate (IRs) | mg/day | 100 | ODEQ 2000; default value for occupational exposure. |
| Exposure Time for Soil (ETs) | hrs/day | 8 | Assumes standard work day. |
| Soil Adherence Factor (AF) | mg/cm2-day | 0.08 | ODEQ 2000; default value for occupational exposure |
| Skin Surface Area for Soil Exposure | cm2 | 2,300 | 50th percentile surface area for hands and forearms, male; USEPA 1997 |
| Inhalation Rate of Air (IRA) | m3/day | 15.2 | ODEQ 2000; default value for occupational exposure |
| Particulate Emission Factor (PEF) | m3/kg | 1.32E+09 | ODEQ 2000; default value |
| **Exposures to Sediment** | | | |
| Sediment Ingestion Rate (IRsed) | mg/day | 100 | ODEQ 2000; default value for occupational exposure. |
| Exposure Time for Sediment (ETsed) | hrs/day | 8 | Assumes standard work day. |
| Sediment Adherence Factor (AFsed) | mg/cm2-day | 0.08 | ODEQ 2000; default value for occupational exposure |
| Skin Surface Area for Sediment Exposure | cm2 | 3,300 | 95th percentile surface area for hands and forearms, male; USEPA 1997 |

**Table B-3. Exposure Point Concentrations**

| COPC | No. of Samples | Maximum Conc'n | UCL90 (a) | Mean | Distribution |
|---|---|---|---|---|---|
| Soils/Wastes (mg/kg) (b) | | | | | |
| Aluminum | 12 | 19,100 | 14,900 | 8,590 | Lognormal |
| Arsenic | 12 | 165 | 65.9 | 38.1 | Lognormal |
| Iron (c) | 11 | 49,800 | 36,600 | 30,100 | Lognormal |
| Surface Water (mg/L) (d) | | | | | |
| Aluminum | 11 | 0.134 | 0.068 | 0.054 | Normal |
| Arsenic (e) | 11 | 0.0028 | 0.0024 | 0.0024 | Normal |
| Iron | 11 | 0.175 | 0.083 | 0.06 | Lognormal |
| Sediment (mg/kg) (f) | | | | | |
| Aluminum | 17 | 42,700 | 15,200 | 12,900 | Lognormal |
| Arsenic | 17 | 55.7 | 40.4 | 28.2 | Lognormal |
| Iron | 17 | 61,100 | 35,400 | 29,400 | Lognormal |

UCL90 = 90 percent confidence limit on the mean

(a) Note: The UCL90 was used to represent the exposure point concentration for the RME scenarios.

(b) Soil/waste data are from Table G-4 of the 2003 SI report and 2004 data collected by SAIC.

(c) Excludes one sample identified as "iron precipitate in gully."
This sample is not representative of potential human exposures at the site.

(d) Surface water data are for total metals as presented on page 148 of the 2003 SI report.

(e) Only one of 11 samples contained arsenic above the detection limit. The normal UCL90 was used to represent the exposure point concentration, however this value likely significantly overestimates the average concentration of arsenic in surface water.

(f) Sediment data are from Table G-3 of the 2003 SI report.

## Table B-4. Noncarcinogenic Toxicity Factors

| COPC | Oral Rfd (mg/kg-day) | Critical Effect | Uncertainty Factor | Source | Inhalation RfD (mg/kg-day) | Critical Effect | Uncertainty Factor | Source |
|---|---|---|---|---|---|---|---|---|
| Aluminum | 1.0E+00 | -- | -- | NCEA | 1.40E-03 | -- | -- | NCEA |
| Arsenic | 3.0E-04 | hyperpigmentation, keratosis, and possible vascular complications | 3 | IRIS | -- | -- | -- | -- |
| Iron | 3.0E-01 | chronic iron overload | 1 | NCEA | -- | -- | -- | -- |

NCEA -- National Center for Environmental Assessment

IRIS -- Integrated Risk Information System (2004)

**Table B-5.  Carcinogenic Toxicity Factors**

| COPC | Oral SF 1/(mg/kg-day) | Type of Cancer | Weight of Evidence | Source | Inhalation SF 1/(mg/kg-day) | Type of Cancer | Weight of Evidence | Source |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 1.5E+00 | Skin | A | IRIS | 15 | Lung | A | IRIS |

IRIS -- Integrated Risk Information System (2004)
SF -- cancer slope factor

**Table B-6. Chemical Intakes: Recreational Visitor**

| Exposure Route | Chemical | EPC | Dermal Absorption Factor (ABS) | Intake Factor (Cancer) | Intake Factor (Noncancer) | Intake (Cancer) | Intake (Noncancer) |
|---|---|---|---|---|---|---|---|
| Incidental Ingestion of Soil/Waste | Aluminum | 14900 | NA | 2.6E-09 | 2.1E-08 | 3.9E-05 | 3.2E-04 |
| | Arsenic | 65.9 | NA | 2.6E-09 | 2.1E-08 | 1.7E-07 | 1.4E-06 |
| | Iron | 36600 | NA | 2.6E-09 | 2.1E-08 | 9.5E-05 | 7.8E-04 |
| Dermal Contact with Soil/Waste | Aluminum | 14900 | NA | 9.9E-08 | 7.2E-07 | NA | NA |
| | Arsenic | 65.9 | 0.03 | 9.9E-08 | 7.2E-07 | 2.0E-07 | 1.4E-06 |
| | Iron | 36600 | NA | 9.9E-08 | 7.2E-07 | NA | NA |
| Inhalation of Particulates | Aluminum | 14900 | NA | 1.8E-12 | 8.0E-12 | 2.6E-08 | 1.2E-07 |
| | Arsenic | 65.9 | NA | 1.8E-12 | 8.0E-12 | 1.2E-10 | 5.3E-10 |
| | Iron | 36600 | NA | 1.8E-12 | 8.0E-12 | 6.5E-08 | 2.9E-07 |
| Ingestion of Surface Water (Drinking Water) | Aluminum | 0.068 | NA | 3.8E-04 | 1.9E-03 | 2.6E-05 | 1.3E-04 |
| | Arsenic | 0.0024 | NA | 3.8E-04 | 1.9E-03 | 9.1E-07 | 4.6E-06 |
| | Iron | 0.083 | NA | 3.8E-04 | 1.9E-03 | 3.2E-05 | 1.6E-04 |
| Incidental Ingestion of Sediment | Aluminum | 15200 | NA | 1.3E-09 | 1.1E-08 | 2.0E-05 | 1.6E-04 |
| | Arsenic | 40.4 | NA | 1.3E-09 | 1.1E-08 | 5.3E-08 | 4.3E-07 |
| | Iron | 35400 | NA | 1.3E-09 | 1.1E-08 | 4.6E-05 | 3.8E-04 |
| Dermal Contact with Sediment | Aluminum | 15200 | NA | 9.9E-08 | 7.2E-07 | NA | NA |
| | Arsenic | 40.4 | 0.03 | 9.9E-08 | 7.2E-07 | 1.2E-07 | 8.7E-07 |
| | Iron | 35400 | NA | 9.9E-08 | 7.2E-07 | NA | NA |

**Table B-7. Chemical Intakes: Maintenance Worker**

| Exposure Route | Chemical | EPC | Dermal Absorption Factor (ABS) | Intake Factor (Cancer) | Intake Factor (Noncancer) | Intake (Cancer) | Intake (Noncancer) |
|---|---|---|---|---|---|---|---|
| Incidental Ingestion of Soil/Waste | Aluminum | 14900 | NA | 9.3E-10 | 2.6E-09 | 1.4E-05 | 3.9E-05 |
| | Arsenic | 65.9 | NA | 9.3E-10 | 2.6E-09 | 6.1E-08 | 1.7E-07 |
| | Iron | 36600 | NA | 9.3E-10 | 2.6E-09 | 3.4E-05 | 9.5E-05 |
| Dermal Contact with Soil/Waste | Aluminum | 14900 | NA | 5.1E-09 | 1.4E-08 | NA | NA |
| | Arsenic | 65.9 | 0.03 | 5.1E-09 | 1.4E-08 | 1.0E-08 | 2.8E-08 |
| | Iron | 36600 | NA | 5.1E-09 | 1.4E-08 | NA | NA |
| Inhalation of Particulates | Aluminum | 14900 | NA | 1.1E-13 | 3.0E-13 | 1.6E-09 | 4.5E-09 |
| | Arsenic | 65.9 | NA | 1.1E-13 | 3.0E-13 | 7.1E-12 | 2.0E-11 |
| | Iron | 36600 | NA | 1.1E-13 | 3.0E-13 | 3.9E-09 | 1.1E-08 |
| Incidental Ingestion of Sediment | Aluminum | 15200 | NA | 9.3E-10 | 2.6E-09 | 1.4E-05 | 4.0E-05 |
| | Arsenic | 40.4 | NA | 9.3E-10 | 2.6E-09 | 3.8E-08 | 1.1E-07 |
| | Iron | 35400 | NA | 9.3E-10 | 2.6E-09 | 3.3E-05 | 9.2E-05 |
| Dermal Contact with Sediment | Aluminum | 15200 | NA | 5.1E-09 | 1.4E-08 | NA | NA |
| | Arsenic | 40.4 | 0.03 | 5.1E-09 | 1.4E-08 | 6.2E-09 | 1.7E-08 |
| | Iron | 35400 | NA | 5.1E-09 | 1.4E-08 | NA | NA |

**Table B-8. Risk Characterization Summary**

| Exposure Scenario | COPC | Noncancer Hazard | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Ingestion (Soil) | Dermal (Soil) | Inhalation of Particulates | Ingestion (surface water) | Ingestion (Sediment) | Dermal (Sediment) | Total |
| Recreational Visitor (Camper) | Aluminum | 3.E-04 | NA | 1.E-04 | 1.E-04 | 2.E-04 | NA | 7.E-04 |
| | Arsenic | 5.E-03 | 5.E-03 | NA | 2.E-02 | 1.E-03 | 3.E-03 | 3.E-02 |
| | Iron | 3.E-03 | NA | NA | 1.E-03 | 1.E-03 | NA | 5.E-03 |
| | **TOTAL** | **8.E-03** | **5.E-03** | **1.E-04** | **2.E-02** | **2.E-03** | **3.E-03** | **4.E-02** |
| Maintenance Worker | Aluminum | 4.E-05 | NA | 4.E-06 | NA | 4.E-05 | NA | 8.E-05 |
| | Arsenic | 6.E-04 | 9.E-05 | NA | NA | 4.E-04 | 6.E-05 | 1.E-03 |
| | Iron | 3.E-04 | NA | NA | NA | 3.E-04 | NA | 6.E-04 |
| | **TOTAL** | **9.E-04** | **9.E-05** | **4.E-06** | **NA** | **7.E-04** | **6.E-05** | **2.E-03** |

| Exposure Scenario | COPC | Cancer Risk | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Ingestion (Soil) | Dermal (Soil) | Inhalation of Particulates | Ingestion (surface water) | Ingestion (Sediment) | Dermal (Sediment) | Total |
| Recreational Visitor (Camper) | Aluminum | NA | NA | NA | NA | NA | NA | NA |
| | Arsenic | 3.E-07 | 3.E-07 | 2.E-09 | 1E-06 | 8.E-08 | 2.E-07 | 2.E-06 |
| | Iron | NA | NA | NA | NA | NA | NA | NA |
| | **TOTAL** | **3.E-07** | **3.E-07** | **2.E-09** | **1.E-06** | **8.E-08** | **2.E-07** | **2.E-06** |
| Maintenance Worker | Aluminum | NA | NA | NA | NA | NA | NA | NA |
| | Arsenic | 1.E-07 | 2.E-08 | 1.E-10 | NA | 6.E-08 | 9.E-09 | 2.E-07 |
| | Iron | NA | NA | NA | NA | NA | NA | NA |
| | TOTAL | **1.E-07** | **2.E-08** | **1.E-10** | **NA** | **6.E-08** | **9.E-09** | **2.E-07** |

**Appendix A-2:  Streamlined Ecological Risk Assessment**

**Bluebird Mine Site**

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# 1.0 INTRODUCTION

In accordance with Oregon Department of Environmental Quality (ODEQ) guidance (ODEQ, 2001), Science Applications International Corporation (SAIC) conducted a Screening Level Ecological Risk Assessment (ERA) for the Bluebird Mine Site (Site) as part of the Engineering Evaluation/Cost Analysis (EE/CA). This ERA is consistent with national and regional guidance (USEPA 1997, 1998). The purpose of the streamlined ERA is to provide an understanding of the potential for ecological risks due to mine-related contamination and to determine whether there is a need for more detailed ecological risk assessment. This report consists of the following:

- A problem formulation that includes identification of contaminants of interest (COIs) based on site uses and existing data
- A description of the ecology of the site and potential ecological receptors (including rare, threatened, and endangered species) at or near the site
- A conceptual site model that provides a summary of potential exposure media and pathways
- Assessment and measurement endpoints
- Risk screening of the COIs in each media to identify contaminants of potential ecological concern (CPECs)
- Risk characterization to assess the potential for significant ecological effects due to site-related contaminants

SAIC visited the site on September 8-10 and on October 5, 2004 to document current ecological conditions at and near the site. An ODEQ ecological scoping checklist was completed and is provided as Attachment A.

# 2.0 PROBLEM FORMULATION

The scope of an ERA is defined through the "Problem Formulation" step that identifies COIs, describes physical and chemical characteristics of the site and describes aquatic and terrestrial resources. This information is utilized to identify ecological receptors of concern and to develop a conceptual site model (CSM) that depicts the expected fate and transport of chemicals at the site, the potential exposure media, and likely exposure pathways for ecological receptors of concern. Ecological assessment and measurement endpoints are selected to focus the ERA on issues of most concern. Where possible, references to relevant EE/CA chapters and previous documents, such as the Site Investigation report (EA Engineering, 2003) are provided as supporting information rather than repeated here.

## 2.1 Contaminants of Interest

This section identifies COIs for surface water, pore water, sediments, and soil/waste materials. Depending on the number of samples in each media, the procedure compares either the maximum media concentration or the 90th upper confidence percentile limit (90UCL) concentration relative to conservative Risk-Based Screening Concentrations (RBSCs) that are considered protective of ecological receptors. Attachment B provides a list and references for each RBSC used in this assessment. In those cases where a published RBSC was below local background reference concentrations, then the background value was used.

### *2.1.1 COIs in Clear Creek Water*

Thirteen water samples in Clear Creek were collected in the summer of 2003 between Stations BLAC 1 through BLUE 8 (see Figure 1 in the EE/CA report and Figures 1 and 2 in EA Engineering 2003). Table 1 compares the range of chemical concentrations with their respective RBSC. Barium exceeded the upstream background concentration (15.8 µg/L) at three site locations; however, the 90UCL concentration is 15.7 µg/L. Barium is not a COI in pore water, sediments, or waste piles and therefore, it will not be evaluated further.

**Table 1: Identification of Contaminants of Interest in Clear Creek Waters**

| Chemical | Range | RBSC | Freq > RBSC | COI ? |
|---|---|---|---|---|
| Aluminum | < 23.6 - 56.9 | 87 | 0/13 | No |
| Antimony | < 4.7 | 30 | 0/13 | No |
| Arsenic | < 2.4 - 4.9 | 150 | 0/13 | No |
| Barium | 13.5 - 17.4 (a) | 15.8 (b) | 3/13 | No |
| Cadmium | < 0.6 | 2.2 | 0/13 | No |
| Calcium | 11,400 - 13,600 | 116,000 | 0/13 | No |
| Chromium | < 0.6 - 1.5 | 11 | 0/13 | No |
| Cobalt | < 2 | 23 | 0/13 | No |
| Copper | < 2.4 | 9 | 0/13 | No |
| Iron (total) | < 16.8 - 58.9 | 1,000 | 0/13 | No |
| Lead | < 1.3 - 1.6 | 2.5 | 0/13 | No |
| Magnesium | 6,520 - 7,860 | 82,000 | 0/13 | No |
| Manganese | 1.9 - 17.3 | 120 | 0/13 | No |
| Mercury (total) | < 0.1 | 0.77 | 0/13 | No |
| Nickel | < 2.1 | 52 | 0/13 | No |
| Potassium | 991 - 1,370 | 53,000 | 0/13 | No |
| Selenium (total) | < 3.4 | 5 | 0/13 | No |
| Sodium | 2,290 - 2,960 | 680,000 | 0/13 | No |
| Vanadium | < 2 - 2.5 | 20 | 0/13 | No |
| Zinc | 1.4 - 8.6 | 120 | 0/13 | No |

Concentrations in µg/L dissolved unless otherwise noted.
total - Total recoverable concentrations.
(a) - 90th percentile UCL for barium is 15.7 µg/L
(b) - RBSC is based on mean + 2 standard deviations of background concentrations in Clear Creek upstream of Blackjack.

### *2.1.2 COIs in Clear Creek Pore Water*

Nineteen pore water samples were collected from Clear Creek between Stations BLAC 1 through BLUE 8 (refer to Figures 1 and 2 in the SI report). Table 2 compares the range of chemical concentrations with their respective RBSC. No contaminants of interest were identified in Clear Creek pore water.

**Table 2: Identification of Contaminants of Interest in Pore Waters of Clear Creek**

| Chemical | Range | RBSC | Freq > RBSC | COI ? |
|---|---|---|---|---|
| Aluminum | < 23.6 – 431 | 87 | 1/19 | No (a) |
| Antimony | < 4.7 - 6.4 | 30 | 0/19 | No |
| Arsenic | < 4.8 | 150 | 0/19 | No |
| Barium | 13 - 30.6 | 23.3 (b) | 1/19 | No (c) |
| Cadmium | < 0.6 | 2.2 | 0/19 | No |
| Calcium | 11,300 - 26,700 | 116,000 | 0/19 | No |
| Chromium | < 0.6 - 1.4 | 11 | 0/19 | No |
| Cobalt | < 2 | 23 | 0/19 | No |
| Copper | < 1.4 - 2.4 | 9 | 0/19 | No |
| Iron (total) | < 16.8 - 399 | 1,000 | 0/19 | No |
| Lead | < 1.5 | 2.5 | 0/19 | No |
| Magnesium | 6,510 - 14,900 | 82,000 | 0/19 | No |
| Manganese | < 0.7 - 61.1 | 120 | 0/19 | No |
| Mercury (total) | < 0.1 - 0.17 | 0.77 | 0/19 | No |
| Nickel | < 2 - 8.5 | 52 | 0/19 | No |
| Potassium | 1,090 - 2,320 | 53,000 | 0/19 | No |
| Selenium (total) | < 3.4 | 5 | 0/19 | No |
| Sodium | 2,710 - 6,570 | 680,000 | 0/19 | No |
| Vanadium | < 2 - 3.1 | 20 | 0/19 | No |
| Zinc | < 1 - 17.6 | 120 | 0/19 | No |

Concentrations in µg/L dissolved unless otherwise noted.
total - Total recoverable concentrations.
(a) - The maximum appears to be an outlier, the next highest value was 53 µg/L. Aluminum is not a CPEC in any other media at Blackjack or Bluebird.
(b) - RBSC is based on background concentration in Clear Creek upstream of Blackjack.
(c) - Barium 90th percentile UCL = 17.9 µg/L, which is less than RBSC.

### *2.1.3 COIs in Clear Creek Sediments*

Twenty sediment samples were collected from Clear Creek between Stations BLAC 1 through BLUE 8 (refer to Figures 1 and 2 in the SI report) Table 3 compares the range and 90UCL concentrations with the RBSCs. Arsenic, chromium (total), cobalt, copper, iron, manganese, mercury (total), and nickel are identified as COIs in the sediments and will be evaluated further. Three samples from Blackjack sediment ponds (not within Clear Creek) also contain these COIs as well as antimony, cadmium, and zinc.

### *2.1.4 COIs in Soils/Wastes*

Twelve solid samples were collected at the Site from a few potential source locations ranging from mine waste rock to material in a former settling pond. Table 4 compares the range and 90UCL concentrations with the soil RBSCs. Antimony, arsenic, chromium (total), copper, iron, lead, manganese, mercury (total), nickel, selenium, silver, thallium, and vanadium are identified as COIs that may be associated with former mining operations. These COIs will be evaluated further in Section 3.

**Table 3: Identification of Contaminants of Interest in Clear Creek Sediments**

| Chemical | Range | 90th UCL * | RBSC | Freq > RBSC | COI ? |
|---|---|---|---|---|---|
| Aluminum | 6,680 - 42,700 | 15,090 | 58,000 | 0/20 | No |
| Antimony | < 0.47 - 5.9 | 2.0 | 3 | 1/20 | No |
| Arsenic | 3.9 - 55.7 | 33.7 | 35.3 (a) | 4/20 | Yes (b) |
| Barium | 40.5 - 405 | 126.5 | 165 | 1/20 | No |
| Beryllium | 0.11 - 1.2 | 0.44 | 2 | 0/20 | No |
| Cadmium | < 0.059 - 4.2 | 0.41 | 0.6 | 1/20 | No |
| Calcium | 1,070 - 6,750 | 3,790 | NA | NA | No |
| Chromium | 10.7 - 193 | 107 | 116 (a) | 6/20 | Yes |
| Cobalt | 9.5 - 85.5 | 28.9 | 27 | 4/20 | Yes |
| Copper | 17.7 - 323 | 37.2 | 36 | 9/20 | Yes |
| Cyanide | < 0.61 | < 0.61 | NA | NA | No |
| Iron | 14,000 - 61,100 | 33,680 | 34,400 (a) | 6/20 | Yes |
| Lead | 1.3 - 11.6 | 4.4 | 35 | 0/20 | No |
| Magnesium | 2,690 - 21,500 | 13,300 | NA | NA | No |
| Manganese | 409 - 3,090 | 1,100 | 1,100 | 2/20 | Yes |
| Mercury | < 0.019 - 0.38 | 0.26 | 0.2 | 2/20 | Yes |
| Nickel | 51.9 - 503 | 181 | 158 (a) | 8/20 | Yes |
| Potassium | 350 - 2,650 | 1,019 | NA | NA | No |
| Selenium | < 0.17 - 2.9 | 0.86 | 4 | 0/20 | No |
| Silver | < 0.22 - 2.6 | 0.87 | 4.5 | 0/20 | No |
| Sodium | 62.3 - 1,040 | 382 | NA | NA | No |
| Thallium | < 0.58 - 2.4 | 1.6 | 8 | 0/20 | No |
| Vanadium | 10.6 - 106 | 53.3 | 64 (a) | NA | No |
| Zinc | 28.8 - 556 | 83.8 | 123 | 1/20 | No |

Concentrations in mg/kg.
* - Does not include background samples (n=18)
(a) - RBSC is based on the mean + 2 standard deviations of background sediment concentrations in pool upstream of Blackjack.
(b) - Although the 90th UCL is < the RBSC, 20% of samples exceed RBSC.

For pond sediments, antimony, cadmium, cobalt, and zinc are included to the list of CPECs.

**Table 4: Identification of Contaminants of Interest in Bluebird Soils/Wastes**

| Chemical | Range (n=12) | 90th UCL | RBSC | Background | COI ? |
|---|---|---|---|---|---|
| Aluminum | 1,970 - 19,100 | 11,050 | 50 * | 27,500 | No |
| Antimony | 0.82 - 45.5 | 11.9 | 5 | 1.2 | Yes |
| Arsenic | 7.3 - 165 | 58.9 | 10 | 8.1 | Yes |
| Barium | 22.6 - 271 | 123 | 85 * | 430 | No |
| Beryllium | 0.12 - 0.63 | 0.39 | 10 | 0.94 | No |
| Cadmium | < 0.023 - 3 | 0.70 | 4 | 0.16 | No |
| Calcium | < 18.1 - 4,040 | 2,360 | NA | 1,880 | No |
| Chromium (total) | 8.6 - 147 | 87.7 | 0.4 * | 12.5 | Yes |
| Chromium (VI) | 0.76 - 4.9 | 2.1 | 410 | < 2.1 | No |
| Cobalt | 3.5 - 31.4 | 18.3 | 20 | 12.9 | No |
| Copper | 37 - 95.3 | 57.3 | 50 * | 52.6 | Yes |
| Iron | 15,300 - 557,000 | 98,800 | 10 * | 35,300 | Yes |
| Lead | 3.8 - 157 | 99.6 | 16 | 8.2 | Yes |
| Magnesium | 573 - 17,500 | 8,310 | NA | 1,910 | No |
| Manganese | 72.5 - 8,270 | 2,090 | 100 * | 1,502 | Yes |
| Mercury (total) | 0.035 - 82 | 7.50 | 0.1 | 0.068 | Yes |
| Nickel | 7.2 - 221 | 107 | 30 * | 39.5 | Yes |
| Potassium | 327 - 3,370 | 1,760 | NA | 1,450 | No |
| Selenium | 1.3 - 25.7 | 8.8 | 1 * | 1.9 | Yes |
| Silver | 0.1 - 53.4 | 7.8 | 2 | 0.53 | Yes |
| Sodium | < 31.4 - 679 | 314 | NA | 358 | No |
| Thallium | 0.88 - 30.9 | 9.6 | 1 * | 1.5 | Yes |
| Vanadium | 3.8 - 93.3 | 44.3 | 2 * | 38.5 | Yes |
| Zinc | 46 - 165 | 89.1 | 50 * | 102 | No |
| Concentrations in mg/kg.<br>* - Minimum RBSC is below local background concentration. | | | | | |

### *2.1.5 Bioaccumulation Screen*

Because mercury in sediments and soils/wastes and selenium in wastes are bioaccumulators, their potential to compromise the food chain will be discussed in Section 4.0. The ODEQ (2001) bioaccumulation screening values for cadmium and thallium are within background levels, and are therefore not considered contaminants of interest.

## 2.2 Ecosystem Potentially at Risk

The local and site-specific ecology are briefly described in this section to provide an understanding of the ecosystem that is potentially at risk. Detailed information on habitat characterizations, plant and animal species, and biological survey methods may be found in EA Engineering (2003).

### *2.2.1 Aquatic Environment*

Clear Creek provides habitat for wild Mid-Columbia spring Chinook salmon (*Oncorhynchus tshawytscha*), a species of special concern, wild Mid-Columbia summer steelhead (*Oncorhynchus mykiss*), listed as threatened under the Endangered Species Act (ESA), and Columbia Basin bull trout (*Salvelinus confluentus*) which is also listed as threatened under ESA. Other salmonid species include redband trout (*O. mykiss gairdneri*) and westslope cutthroat trout (*O. clarki lewisi*).

Within the project vicinity, Clear Creek has undergone extensive stream restoration activities for improving salmon habitat, largely as part of the North Fork John Day Dredge Tailings Restoration Project (BPA 2002). The restoration project largely occurred between 2000 and 2003 with riparian revegetation enhancements continuing into 2003.

Prior to the 1980s, the mine water from the Site discharged directly into Clear Creek, affecting water quality and resulting in iron precipitate coatings on the stream substrate. Since the 1980s, the USFS piped the adit water into side channel ponds to reduce the flow entering the creek. The current channel pond that receives Site water is in the Clear Creek floodplain, separated from the creek by a roadbed and dredge piles, and is well vegetated. Iron and associated heavy metals precipitate in the ponds and the remaining water filters through the floodplain materials (e.g., gravels, cobbles, and boulders), mixing with shallow groundwater and potentially reentering the stream.

The fish and macroinvertebrate communities of Clear Creek may be exposed to contaminants in mine water from potential failures of the existing discharge pipe or failure of the side sediment pond that receives the mine water. Aquatic organisms in the creek may also be exposed to discharge of contaminated shallow groundwater reentering from the settling ponds.

### *2.2.2 Terrestrial Environment*

The Site is located on a sloping hillside with a western aspect and moderately forested with coniferous trees. A large waste rock pile located adjacent and south of the mine portal is partially vegetated with trees approximately 1-10 years old. The side-slope of this pile and a pile north of the portal is sparsely vegetated. The understory vegetation across the site is sparse with grasses and forbs, with the exception in the former mill area (north and downslope of the portal) where there are thick grasses and sedges. The riparian vegetation on the west side of the Clear Creek flood plain is sparse and has recently been supplemented by restoration plantings of mixed trees and shrubs approximately 2-4 years old. The east bank of the creek is entrenched with some erosion of the bank downstream of the pipeline crossing.

Plants growing on contaminated soils or waste materials may uptake and bioaccumulate chemicals that may become toxic or could be transferred through the food web. Local small mammals and ground birds (e.g., grouse) may be exposed to contaminants in waste rock piles and from the wetland area near the mill remnants that formally received mine water discharge. Larger mammals and birds with greater home ranges may occasionally be exposed to the mine waste materials.

## 2.3 Conceptual Site Model

In this section, a site conceptual model is developed to depict sources of contamination, potential contaminant release and transport mechanisms, impacted exposure media, and exposure routes for ecological receptor types at the site (Figure 1). The primary sources of the COIs are the Bluebird mine adit discharge and mining-related waste piles. The waste piles are subject to some erosion.

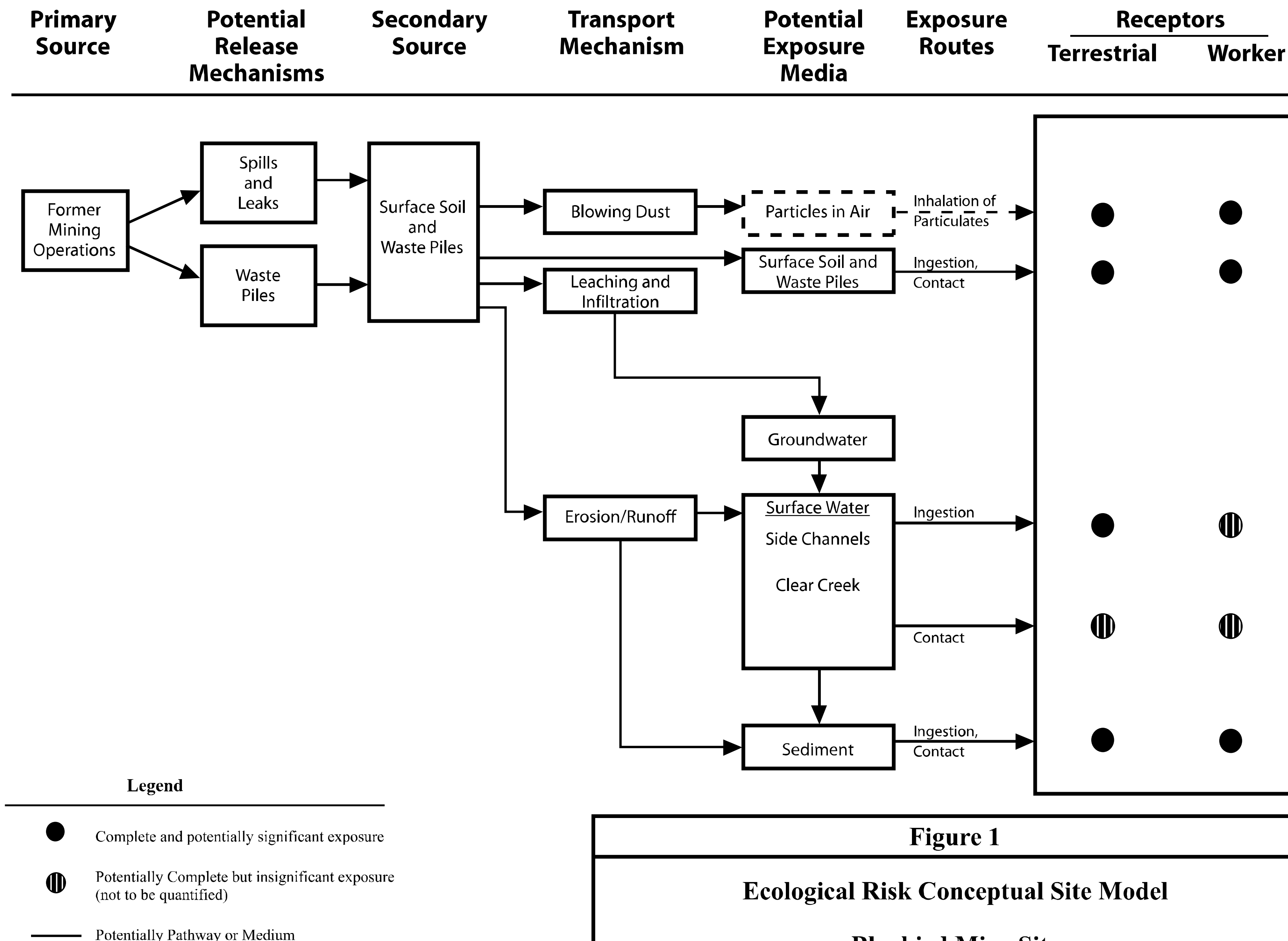


**Figure 1**

**Ecological Risk Conceptual Site Model**

**Bluebird Mine Site**

Much of the iron precipitate or eroded materials that historically entered the creek and deposited into the sediments was disturbed, relocated or dispersed by the recent stream restoration activities. The outfall of the Site mine water discharges into a pond located west of the County Road and continues to flow downstream for approximately 600 feet to where it is planned to cross the road again (currently a plugged culvert) into another shallow depression east of the road and approximately 50 feet from Clear Creek. This water may provide some exposure to wildlife and potentially some seepage back into the creek.

There has been no discharge of mine water into the creek in the vicinity of the Site due to the plugged culvert. The inlet of the culvert became clogged over time, likely due to vegetative material or sediment deposits. Instead, the mine water continues flowing north along the west side of the County Road (on private land) and eventually seeps into the floodplain. The surface water, sediment, and biota collected as part of the SI reflect this existing condition. However, the data do not reflect the scenarios of mine water release into the creek that may occur from unplugging the culvert. Consequently, a data gap exists regarding the potential impacts/effects to aquatic life after the culvert becomes unplugged. A data gap also exist in Clear Creek farther downstream where the current mine water is mixing.

The COIs may bioaccumulate in plant or animal tissues and be transported through the food chain (especially mercury). Figure 1 provides a graphic representation of the conceptual site model for the Site.

## 2.4 Assessment and Measurement Endpoints

Assessment endpoints, listed below, are qualitative or quantitative expressions of the environmental values to be protected and are used to link the ERA and risk management processes by highlighting ecological aspects that are of concern to risk managers. Measurement endpoints, also listed below, are characteristics of the site, receptors, or ecological data that are measured through sampling or monitoring, and then related qualitatively or quantitatively to the selected assessment endpoints.

### *2.4.1 Assessment Endpoints*

- Protect salmonid species of concern and their associated aquatic habitat (including macroinvertebrates) from adverse effects due to contaminants in Clear Creek.
- Protect small mammals and ground birds from adverse effects of contaminants in soils and wastes.
- Protect vegetation from adverse effects from contaminants in soils and water.

### *2.4.2 Measurement Endpoints*

- Measured concentrations of chemicals in soil, waste piles, surface water, pore water, and sediment and plant tissue.
- Other chemistry data such as soil leach tests results, acid generation potential, pH, and redox potential.
- Benthic macroinvertebrate surveys and fish population data.
- Readily available ecological risk-based screening concentrations (RBSCs) available from ODEQ guidance or other readily available published literature.

### 2.5 Data Usability

Standard field and laboratory quality control procedures were used and analytical results were quality assured by the laboratory. The analytical data are considered good quality and useable for the ERA.

The Site soil/waste data were collected from five primary sources:

- The south waste rock pile near the adit portal, represented by one composite sample from 7 locations and one discrete sample.
- North and west waste rock pile, represented by 2 discrete samples and one composite sample of 7 locations.
- Former mill site area, represented by one discrete sample.
- Iron precipitation in the gully downslope of the portal - one sample.
- Other areas on the site.

## 3.0 ECOLOGICAL RISK-BASED SCREENING

This section identifies contaminants of potential ecological concern (CPECs) by comparing the media concentrations of the COIs identified in Section 2.1 with RBSCs specific to aquatic life; or to plants, invertebrates, birds, and mammals in the terrestrial ecosystem. The exposure point concentrations are represented by either the 90UCL or maximum concentration, depending on sample size for the source area. One-half the analytical reporting limit was used in these calculations when a particular result was listed as not detected.

Generally, the RBSCs used in the risk-based screening were the screening level values cited in ODEQ (2001). Exceptions to this are referenced in Attachment B. The ratio of the media exposure concentration to the RBSCs results in a risk ratio or hazard quotient, and defines a CPEC. Risk ratios greater than 1 indicates a potential risk for protected (i.e., federally threatened or endangered) species, while a risk ratio of 5 or greater indicates a potential risk for non-protected receptors (ODEQ 2001). The predicted risks for the CPECs are discussed further in the risk characterization section.

### 3.1 Risk Screening of Sediments in Clear Creek

Table 5 compares the 90UCL concentration of the COIs from both pool and riffle habitats to their respective sediment conservative screening values. The risk ratios ranged from 0.8 for arsenic to 1.3 for iron. Mercury and copper risk ratios were 1.1 and 1.2, respectively. These low ratios suggest that the site sediment concentrations have low potential for risks and approach near reference background levels.

The sediment concentrations reflect only the fine sediment particles that are collected for analysis. These fine sediments represent a small fraction of the exposure medium in mountain streams. Most benthic macroinvertebrates in mountain streams are not fine sediment dwellers but rather utilize boulders, cobbles, gravels, and woody debris. Therefore, the risk ratios are considered over-conservative for potential effects to aquatic invertebrates in Clear Creek.

**Table 5: Risk-Based Screening of Sediments in Clear Creek Potentially Influenced by Bluebird Mine**

| COI | 90UCL Concentration | Sediment Screening Value | Ratio |
|---|---|---|---|
| Arsenic | 29.1 | 35.3 | 0.8 |
| Chromium | 88.8 | 116 | 0.8 |
| Cobalt | 23.3 | 27 | 0.9 |
| Copper | 42.7 | 36 | 1.2 |
| Iron | 43,610 | 34,400 | 1.3 |
| Manganese | 899 | 1,100 | 0.8 |
| Mercury | 0.22 | 0.2 | 1.1 |
| Nickel | 145 | 158 | 0.9 |
| All concentrations in mg/kg | | | |

### 3.2 Risk Screening of Bluebird Soil/Waste Areas

For this risk screening, the available site data has been segregated to be most representative of exposures to potential source areas, as listed in Section 2.5. ODEQ (2001) risk-based screening levels for terrestrial receptors (plants, soil invertebrates, birds, and mammals) were used to compare to the concentrations of COIs in these two source areas. Table 6 presents the terrestrial screening results.

The highest risk ratios were from mercury, arsenic, antimony, and silver in the sample from the former mill site. These ratios ranged from 9 for antimony to 820 for mercury, suggesting the likelihood of adverse risks to terrestrial receptors. Because mercury is very bioaccumulative, the threat for mercury to enter the food chain may also be of concern. However, this sample is only representative of approximately 22 cubic feet of material, and vegetation is growing over this small waste source.

The iron precipitate in the gully is of potential concern with risk ratios exceeding 1 for arsenic, iron, mercury, selenium, and thallium. This material is comprised mainly of precipitated iron oxide and oxyhydroxide metal complexes from the former uncontrolled mine water discharge from Bluebird that created the gully. The precipitate volume is approximately 20 cubic feet (40 feet long x 3 feet wide x 2 inches deep).

Risk ratios for the northwest waste rock area and the south waste rock pile were relatively low (ratio <5) with arsenic and lead having the most potential to affect birds.

The other areas include the edge of the former settling pond (which is heavily vegetated) and iron-stained soils downgradient of the west waste rock area closer to Clear Creek. Risk ratios for arsenic, iron, mercury, and manganese are greater than 1.0 but less than 5 suggesting low potential for ecological risks. Small fir trees and grasses are growing in all these areas, with no evidence of vegetative stress. The former settling pond area is well vegetated with sedges and grasses. Test pits dug in this area show a heavily iron-stained top layer of fine precipitate-like material, with an under-layer of soils stained black-gray by a reduced environment. There was no evidence of petroleum-related contamination.

**Table 6: Risk-Based Screening of Bluebird Mine Soil/Waste Materials**

| | *Antimony* | *Arsenic* | *Chromium* | *Copper* | *Iron* | *Lead* | *Manganese* | *Mercury* | *Nickel* | *Selenium* | *Silver* | *Thallium* | *Vanadium* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RBSC** | | | | | | | | | | | | | |
| Plants | 5 | 10 | 12.5 * | 100 | 35300* | 110 | 1502 | 0.3 | 39.5 * | 1.9 * | 2 | 1.5 * | 38.5 * |
| Invertebrates | 78 | 60 | 12.5 * | 52.6 * | 35300* | 1700 | 1502 | 0.1 | 200 | 70 | 50 | | |
| Birds | | 10 | 12.5 * | 190 | | 16 | 4125 | 1.5 | 320 | 2 | | | 47 |
| Mammals | 15 | 29 | 410 | 390 | | 59 | 11000 | 73 | 625 | 25 | | 1.5 | 38.5 |
| **Northwest Waste Rock Area** | | | | | | | | | | | | | |
| Concentration | 0.33 | 13.8 | 80.4 | 52.3 | 23500 | 157 | 288 | 0.395 | 18.1 | 0.74 | 0.25 | 0.05 | 22.6 |
| ***Risk Ratio[1]*** | | | | | | | | | | | | | |
| Plants | 0.1 | 1.4 | 6.4 | 0.5 | 0.7 | 1.4 | 0.2 | 1.3 | 0.5 | 0.4 | 0.1 | 0.0 | 0.6 |
| Invertebrates | 0.0 | 0.2 | 6.4 | 0.9 | 0.7 | 0.1 | 0.2 | 4.0 | 0.1 | 0.0 | 0.0 | | |
| Birds | | 1.4 | 6.4 | 0.3 | | 9.8 | 0.1 | 0.3 | 0.1 | 0.4 | | | 0.5 |
| Mammals | 0.0 | 0.5 | 0.2 | 0.1 | | 2.7 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.6 |
| **South Waste Rock Pile** | | | | | | | | | | | | | |
| Concentration | 0.53 | 34.6 | 55.6 | 37.5 | 20400 | 81 | 284 | 0.538 | 11 | 0.75 | 0.25 | 0.05 | 20 |
| ***Risk Ratio[1]*** | | | | | | | | | | | | | |
| Plants | 0.1 | 3.5 | 4.4 | 0.4 | 0.6 | 0.7 | 0.2 | 1.8 | 0.3 | 0.4 | 0.1 | 0.0 | 0.5 |
| Invertebrates | | 0.6 | 4.4 | 0.7 | 0.6 | 0.0 | 0.2 | 5.4 | 0.1 | 0.0 | 0.0 | | |
| Birds | | 3.5 | 4.4 | 0.2 | | 5.1 | 0.1 | 0.4 | 0.0 | 0.4 | | | 0.4 |
| Mammals | 0.0 | 1.2 | 0.1 | 0.1 | | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.5 |
| **Former Mill Site** | | | | | | | | | | | | | |
| Concentration | 45.5 | 165 | 102 | 26.4 | 15900 | 129 | 72.7 | 82 | 7.5 | 13.9 | 53.4 | 0.05 | 4.02 |
| ***Risk Ratio[1]*** | | | | | | | | | | | | | |
| Plants | 9.1 | 17 | 8.2 | 0.3 | 0.5 | 1.2 | 0.0 | 273 | 0.2 | 7.3 | 27 | 0.0 | 0.1 |
| Invertebrates | | 2.8 | 8.2 | 0.5 | 0.5 | 0.1 | 0.0 | 820 | 0.0 | 0.2 | 1.1 | | |
| Birds | | 17 | 8.2 | 0.1 | | 8.1 | 0.0 | 55 | 0.0 | 7.0 | | | 0.1 |
| Mammals | 3.0 | 5.7 | 0.2 | 0.1 | | 2.2 | 0.0 | 1.1 | 0.0 | 0.6 | | 0.0 | 0.1 |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

| | *Antimony* | *Arsenic* | *Chromium* | *Copper* | *Iron* | *Lead* | *Manganese* | *Mercury* | *Nickel* | *Selenium* | *Silver* | *Thallium* | *Vanadium* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Iron Precipitate in Gully** | | | | | | | | | | | | | |
| Concentration | 20.2 | 44.3 | 14.6 | 37 | 557000 | 29.1 | 260 | 0.25 | 46.9 | 25.7 | 0.84 | 30.9 | 3.8 |
| ***Risk Ratio***[1] | | | | | | | | | | | | | |
| Plants | 4.0 | 4.4 | 1.2 | 0.4 | 15.8 | 0.3 | 0.2 | 0.8 | 1.2 | 13.5 | 0.4 | 20.6 | 0.1 |
| Invertebrates | | 0.7 | 1.2 | 0.6 | 15.8 | 0.0 | 0.2 | 2.5 | 0.2 | 0.4 | 0.0 | | |
| Birds | | 4.4 | 1.2 | 0.2 | | 1.8 | 0.1 | 0.2 | 0.1 | 12.9 | | | 0.1 |
| Mammals | 1.3 | 1.5 | 0.0 | 0.1 | | 0.5 | 0.0 | 0.0 | 0.1 | 1.0 | | 20.6 | 0.1 |
| **Other Areas** | | | | | | | | | | | | | |
| 90UCL conc | 2.4 | 22.5 | 118 | 72.5 | 42500 | 9.4 | 5800 | 0.42 | 165 | 4.1 | 0.68 | 5.4 | 109 |
| ***Risk Ratio***[1] | | | | | | | | | | | | | |
| Plants | 0.5 | 2.3 | 9.4 | 0.7 | 1.2 | 0.1 | 3.9 | 1.4 | 4.2 | 2.2 | 0.3 | 3.6 | 2.8 |
| Invertebrates | | 0.4 | 9.4 | 1.4 | 1.2 | 0.0 | 3.9 | 4.2 | 0.8 | 0.1 | 0.0 | | |
| Birds | | 2.3 | 9.4 | 0.4 | | 0.6 | 1.4 | 0.3 | 0.5 | 2.1 | | | 2.3 |
| Mammals | 0.2 | 0.8 | 0.3 | 0.2 | | 0.2 | 0.5 | 0.0 | 0.3 | 0.2 | | 3.6 | 2.8 |

- Based on maximum background soil RBSC.

1. Risk ratios <1.0 indicate no risks.
   Risk ratios >1.0 and <5.0 suggest potential risk to threatened and endangered species.
   Risk ratios >5.0 suggest potential risk to non-T&E species.
   (There are no terrestrial T&E species known to utilize the Site.)

## 4.0 RISK CHARACTERIZATION

This section provides a description of risks that involves evaluating the risk ratio estimates presented in Section 3 relative to other site information and uncertainties to characterize the potential for ecological risks at the site.

The primary assessment endpoint related to the Site is protecting threatened and endangered species that reside in Clear Creek and their habitat. The protection of local and transient terrestrial receptors from hazardous substances is also important.

### 4.1 Risks to Aquatic Resources in Clear Creek

Based on existing site data, there were no contaminants of interest identified in Clear Creek surface waters and pore waters. This suggests that fish populations and macroinvertebrate communities are not impacted by hazardous substances release from the Site. To further evaluate if this may be true, an examination of the available fish and macroinvertebrate data is needed.

EA Engineering (2003) collected benthic macroinvertebrate data from seven stations in Clear Creek, one station in a side channel, and one upstream reference background station (see Figures 1 and 2 in the SI for sample locations). EA Engineering developed macroinvertebrate metric scores using ODEQs Biotic Index methodology that provides a measure of the relative condition or health of the benthic community. The higher the score, the more diverse and productive the community is. Table 7 summarizes the metric scores for both pool and riffle habitats. The data indicate no significant differences between the reference station and any of the downstream stations, even after a known release of approximately 70,000 gallons of Blackjack mine water discharge directly into the creek. From Table 7, the BLAC-2 pool station after the spill was slightly lower, but not distinguishable with natural variability, even though visible iron flocculent precipitate was noted in the pool (EA Engineering 2003). Station BLAC-42 in the side channel, upstream from Bluebird, had the highest macroinvertebrate score, even though it had the highest metal sediment concentrations.

**Table 7: Clear Creek Macroinvertebrate Metric Scores [a]**

| Station | Before Spill [b] | | 11 Days After Spill | |
|---|---|---|---|---|
| | Pool Habitat | Riffle Habitat | Pool Habitat | Riffle Habitat |
| BLAC-1 - Upstream | 30 | 40 | 24 | 36 |
| BLAC-2 | 34 | 40 | 20 | 42 |
| BLAC-3 | 30 | 38 | 26 | 36 |
| BLAC-4 | 34 | 34 | NC | NC |
| BLAC-42 | NC | 42 | NC | NC |
| BLUE-5 | 34 | 38 | 32 | 40 |
| BLUE-6 | 28 | 42 | NC | NC |
| BLUE-7 | 30 | 40 | NC | NC |
| BLUE-8 - Downstream | 30 | 38 | NC | NC |

a - Source: EA Engineering (2003) using ODEQ Biotic Index level 3 methods.
b - Spill occurred on July 29, 2003 of approx. 70,000 gal from the upper Blackjack adit with visible iron plume about one mile downstream. Macroinvertebrate community re-evaluated on August 9.
NC - Data not collected.

Fish population data were also collected by EA Engineering before and after the Blackjack spill. Table 8 shows the number of fish species collected at each station. The data indicate no apparent affects on fish populations or diversity in Clear Creek from the mine or the spill. For example, at BLAC-2 and BLUE-5, there were more redband trout and torrent sculpin in the pool after the spill than before the spill. BLAC-42 is a side channel upstream of the Site where dace and sculpins (species that are more associated with benthic substrate and lower flows) typically frequent. The higher sediment metal concentrations at this station did not appear to influence their use at this location.

Habitat assessment scores were also developed by EA Engineering (2003), and are summarized in Table 9. The data indicate that physical habitat conditions are not a limiting factor for supporting healthy macroinvertebrate and fish communities.

**Table 8: Fish Population Data in Clear Creek [a]**

| Station | Chinook Salmon | Redband Trout | Speckled Dace | Torrent Sculpin | Paiute Sculpin |
|---|---|---|---|---|---|
| BLAC-1 | ~ 100 / 3 | 2 / 5 | 2 / 0 | 3 / 0 | 0 / 0 |
| BLAC-2 | 10 / 100 | 0 / 10 | 0 / 0 | 0 / 2 | 0 / 0 |
| BLAC-3 | 75 / 0 | 0 / 5 | 1 / 0 | 3 / 2 | 0 / 1 |
| BLAC-4 | 60 | 1 | 20 | 2 | 0 |
| BLAC-41 | 0 | 4 | 0 | 3 | 0 |
| BLAC-42 | 0 | 0 | 51 | 3 | 0 |
| BLUE-5 | 60 / 5 | 0 / 10 | 30 / 2 | 1 / 6 | 0 / 0 |
| BLUE-6 | 0 | 1 | 10 | 1 | 0 |
| BLUE-7 | 10 | 0 | 50 | 3 | 0 |
| BLUE-8 | 20 | 0 | 75 | 2 | 0 |

a - Source: EA Engineering (2003).
First number in cell indicates population prior to spill; second number is population after spill.

**Table 9: Clear Creek Aquatic Habitat Assessment Scores**

| Station | Score |
|---|---|
| BLAC-1 – Upstream | 176 |
| BLAC-2 | 169 |
| BLAC-3 | 171 |
| BLAC-4 | 183 |
| BLAC-42 | 147 |
| BLUE-5 | 151 |
| BLUE-6 | 167 |
| BLUE-7 | 180 |
| BLUE-8 – Downstream | 182 |

Source: EA Engineering (2003).
Potential maximum score is 200.
Highest siltation occurred at BLUE-5 and BLAC-42 (side channel) - resulted in lower scores for embeddedness.

In summary, the weight-of-evidence of water quality, sediment quality, habitat conditions, fish population, and macroinvertebrate community data indicate that Clear Creek is not being impacted by the current configurations at the Site. However, the mine water and associated pond sediments have been discharged west of the County Road and are migrating off USFS administrated lands onto private property due to a plugged culvert downgradient of the adit discharge. Should the culvert become unplugged, there is likely to be a release of contaminated mine water and sediments back into Clear Creek. The long-term effects from an unplugged culvert to the biota of Clear Creek downstream of the Site cannot be predicted from existing data.

## 4.2 Risk Characterization of Terrestrial Receptors

### *4.2.1 Settling Ponds*

Terrestrial receptors are exposed to hazardous substances that primarily occur in waste piles or the former settling pond. The precipitate material in the former settling pond near the mill site area does not appear to adversely threaten terrestrial receptors. The pond size is small (approximately 100 feet by 50 feet) and is blanketed by a thick layer of sedges and grasses. Deer, bird, and small mammal tracks were also observed in the former pond.

The iron-metal precipitates in the current Bluebird mine water discharge pond west of the County Road is likely to result in some risks to macroinvertebrates that may attempt to colonize the pond bottom. The concentrations of arsenic, cobalt, iron, manganese, nickel, and zinc are notably high relative to sediment screening values. However, the ponds are considered necessary for containing the mine water and precipitating the heavy metals that would otherwise enter Clear Creek. Vegetation in the current settling pond varies depending on water depth and extent of settled precipitate. In general, the thicker the precipitate, the less emergent vegetation is observed. The cattails and sedges appear most tolerant. Birds, mammals, reptiles and amphibians may drink from the pond water but a substantial portion of the metals have been precipitated with the iron and manganese out of the water column, and is not expected to pose an adverse threat.

Some of the mine water and associated precipitates in the settling pond may eventually filter through the substrate and seep into Clear Creek. Based on available surface water, pore water, and sediment data, there is no evidence of significant seepage to the creek in the vicinity of the Site under the current configuration (i.e., with a plugged culvert). However, should pond water and precipitates enter Clear Creek, then there may be a potential for adverse risks.

### *4.2.2 Waste Piles*

As mentioned in Section 3.2, several contaminants collectively pose a threat to local terrestrial receptors. Vegetation on the south and northwest waste rock areas are limited to scattered fir trees and some grasses. The physical characteristics of the rock material (e.g., no soil horizons) and lack of nutrients restrict vegetation growth, and the rocky material does not provide quality habitat for soil organisms or vertebrates to utilize the waste pile area. Plant tissue data from the Site did not show unusual levels of metals uptake, with most metals being within background tissue concentrations. Some of the waste rock piles have steep slopes and may erode, but not into the creek, with the exception of the loose material along the pipeline access route. Leach test samples from the waste areas indicate that contaminant release potential is low and not of regulatory concern and indicate that the elevated metal concentrations in the rock material has low potential for bioavailability to terrestrial receptors. Given these conditions, the relatively low risk ratios, and small size of the waste material (approximately 1.5 acre), risks to terrestrial receptors is considered low.

### 4.3 Uncertainty Analysis

Overall, the data used in this assessment conservatively represent exposure and toxicity. Thus, the estimated risks using the screening-level approach likely overestimate actual risks at the site. The use of maximum detected concentrations or 90UCL as the exposure concentrations is a conservative approach purposefully designed to result in some overestimation of the potential for ecological risks. The screening-level values are also based on very conservative toxicity information to sensitive organisms that may or may not be relevant at the Site.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

There was sufficient information to characterize potential contamination and ecological risks at the site. Although it is likely that individual terrestrial receptors may be at risk within a localized area, receptor populations in the vicinity of the Site are unlikely to be significantly impacted by the localized and small exposure areas to source materials. Any habitat loss from waste rock piles is also unlikely to result in adverse effects to species due to the large amount of relatively undisturbed habitats available in the immediately surrounding area. Small volumes of iron and manganese-stained soil (with low hazard ratios) near the old sediment pond on the east bank of Clear Creek are eroding, but are not considered to be mobilizing substantial contaminants into the creek.

Although the small amount of material found at the former mill site area and the iron-metal precipitate in the gully (approximately 42 cubic feet, collectively) could pose an adverse threat to highly localized wildlife and plants, these materials will not result in adverse toxic responses to wildlife populations of the area.

Because significant risks are not predicted for terrestrial ecological receptors in the waste rock areas, use of soil RBSCs as preliminary remediation goals (PRGs) would be too conservative and no site-specific numerical PRG concentrations for the contaminants in waste rock are necessary.

Because the long-term effects to Clear Creek cannot be predicted if the settling pond becomes unplugged, it is recommended that additional data be collected as described in Section 5 of the EE/CA prior to unplugging the culvert.

## 6.0 REFERENCES

EA Engineering, Science, and Technology, Inc (EA Engineering). 2003. Site Inspection, bluebird and Blackjack Mines, Umatilla National Forest, Oregon. Prepared for U.S. Department of Agriculture – Forest Service, North Fork John Day Ranger District. December 2003.

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

U.S. Environmental Protection Agency (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.

**Attachment A: ODEQ Ecological Scoping Checklist**
**Streamlined Ecological Risk Assessment**
**Bluebird Mine Site**

## Ecological Scoping Checklist

| | |
|---|---|
| **Site Name** | Bluebird Abandoned Mine Site |
| **Date of Site Visit** | Sept 8 9, 10 2004 |
| **Site Location** | Umatilla National Forest near Granite |
| **Site Visit Conducted by** | |

Part ❶

| CONTAMINANTS OF INTEREST<br>Types, Classes, Or Specific Hazardous Substances‡<br>Known Or Suspected | Onsite | Adjacent to or in locality of the facility† |
|---|---|---|
| Mining-related wastes | X | X |
| Heavy Metals | X | X |
| Mercury | X | X |
| | | |
| | | |
| | | |
| | | |

‡ As defined by OAR 340-122-115(30) † As defined by OAR 340-122-115(34)

Part ❷

| OBSERVED IMPACTS ASSOCIATED WITH THE SITE | Finding |
|---|---|
| Onsite vegetation (**N**one, **L**imited, **E**xtensive) | L |
| Vegetation in the locality of the site (**N**one, **L**imited, **E**xtensive) | E |
| Onsite wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other (**N**one, **L**imited, **E**xtensive) | L |
| Wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other in the locality of the site (**N**one, **L**imited, **E**xtensive) | E |
| Other readily observable impacts (**N**one, **D**iscuss below) | D |

Discussion:

Large waste rock pile south of mine portal –
Smaller waste rock pile north of portal (~ half south size)

Vegetation (small trees 5 – 15 yrs) growing on wasterock piles

Potential millsite area – also received AMD discharge – wet area (no trees)

Erosion gullies evident

1 of 6

Bluebird

# Ecological Scoping Checklist (cont'd)

Part ❸

| SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT | Finding |
|---|---|
| ***Terrestrial - Wooded*** | |
| Percentage of site that is wooded | 60 |
| Dominant vegetation type (**E**vergreen, **D**eciduous, **M**ixed) | **P** * |
| Prominent tree size at breast height, i.e., four feet (<6", 6" to 12", >12") | |
| Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther) | |
| ***Terrestrial - Scrub/Shrub/Grasses*** | |
| Percentage of site that is scrub/shrub | 30 |
| Dominant vegetation type (**Sc**rub, **Sh**rub, **G**rasses, **O**ther) | Sh/G **P** |
| Prominent height of vegetation (<2', 2' to 5', >5') | 2-5 |
| Density of vegetation (**D**ense, **P**atchy, **S**parse) | Patchy **P** |
| Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther) | Mac, B, M |
| ***Terrestrial - Ruderal*** | |
| Percentage of site that is ruderal | 10 % |
| Dominant vegetation type (**L**andscaped, **A**griculture, **B**are ground) | Bare **P** |
| Prominent height of vegetation (0', >0' to <2', 2' to 5', >5') | — |
| Density of vegetation (**D**ense, **P**atchy, **S**parse) | P **P** |
| Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther) | Mac, M, B |
| ***Aquatic - Non-flowing (lentic)*** | |
| Percentage of site that is covered by lakes or ponds | 0 |
| Type of water bodies (**L**akes, **P**onds, **V**ernal pools, **I**mpoundments, **La**goon, **R**eservoir, **C**anal) | |
| Size (acres), average depth (feet), trophic status of water bodies | |
| Source water (**R**iver, **S**tream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff) | |
| Water discharge point (**N**one, **R**iver, **S**tream, **G**roundwater, **W**etlands impoundment) | |
| Nature of bottom (**M**uddy, **R**ocky, **S**and, **C**oncrete, **O**ther) | **P** |
| Vegetation present (**S**ubmerged, **E**mergent, **F**loating) | **P** |
| Obvious wetlands present (**Y**es / **N**o) | |
| Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther) | |
| ***Aquatic - Flowing (lotic)*** | |
| Percentage of site that is covered by rivers, streams (brooks, creeks), intermittent streams, dry wash, arroyo, ditches, or channel waterway | 10 % |
| Type of water bodies (**Ri**vers, **S**treams, **I**ntermittent Streams, **Dr**y wash, **Ar**royo, **D**itches, **C**hannel waterway) | Stream |
| Size (acres), average depth (feet), approximate flow rate (cfs) of water bodies | 2' **P** |
| Bank environment (cover: **V**egetated, **Ba**re / slope: **S**teep, **G**radual / height (in feet)) | G 2' |
| Source water (**R**iver, **S**tream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff) | S |
| Tidal influence (**Y**es / **N**o) | No |

Clear Creek

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Bluebird

| SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT | Finding |
|---|---|
| Water discharge point (**N**one, **R**iver, **S**tream, **G**roundwater, **W**etlands impoundment) | S |
| Nature of bottom (**M**uddy, **R**ocky, **S**and, **C**oncrete, **O**ther) | R |
| Vegetation present (**S**ubmerged, **E**mergent, **F**loating) | E **P** |
| Obvious wetlands present (**Y**es / **N**o) Y | floodplain |
| Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther) | Mac, B, M |
| ***Aquatic - Wetlands*** | |
| Obvious or designated wetlands present (**Y**es / **N**o) | |
| Wetlands suspected as site is/has (**A**djacent to water body, in **F**loodplain, **S**tanding water, **D**ark wet soils, **Mu**d cracks, **D**ebris line, **W**ater marks) | Dark soils |
| Vegetation present (**S**ubmerged, **E**mergent, Scrub/shrub, **W**ooded) | E **P** |
| Size (acres) and depth (feet) of suspected wetlands | 0.5 |
| Source water (**R**iver, **S**tream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff) | Su |
| Water discharge point (**N**one, **R**iver, **S**tream, **G**roundwater, **I**mpoundment) | I / S |
| Tidal influence (**Y**es / **N**o) | No |
| Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther) | Mac, B, M. |

* **P**: Photographic documentation of these features is highly recommended.

Part ❹

| ECOLOGICALLY IMPORTANT SPECIES/HABITATS OBSERVED |
|---|
| Clear Creek Salmon stream |
| chinook, other salmonids |
| Restoration on east bank, log wiers, etc. |

Bluebird

## Evaluation of Receptor-Pathway Interactions

| EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS | Y | N | U |
|---|---|---|---|
| **Are hazardous substances present or potentially present in surface waters?** | | | X |
| **AND** | | | |
| **Are ecologically important species or habitats present?** | X | | |
| **AND** | | | |
| **Could hazardous substances reach these receptors via surface water?** | X | | |
| When answering the above questions, consider the following:<br>• Known or suspected presence of hazardous substances in surface waters.<br>• Ability of hazardous substances to migrate to surface waters.<br>• Terrestrial organisms may be dermally exposed to water-borne contaminants as a result of wading or swimming in contaminated waters. Aquatic receptors may be exposed through osmotic exchange, respiration or ventilation of surface waters.<br>• Contaminants may be taken-up by terrestrial plants whose roots are in contact with surface waters.<br>• Terrestrial receptors may ingest water-borne contaminants if contaminated surface waters are used as a drinking water source. | | | |
| **Are hazardous substances present or potentially present in groundwater?** Acid Mine Drainage | X | | |
| **AND** | | | |
| **Are ecologically important species or habitats present?** | X | | |
| **AND** | | | |
| **Could hazardous substances reach these receptors via groundwater?** Currenty diverted away | | | X |
| When answering the above questions, consider the following:<br>• Known or suspected presence of hazardous substances in groundwater. AMD<br>• Ability of hazardous substances to migrate to groundwater.<br>• Potential for hazardous substances to migrate via groundwater and discharge into habitats and/or surface waters.<br>• Contaminants may be taken-up by terrestrial and rooted aquatic plants whose roots are in contact with groundwater present within the root zone (~1m depth).<br>• Terrestrial wildlife receptors generally will not contact groundwater unless it is discharged to the surface. | | | |

**"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")**

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Bluebird

**Evaluation of Receptor-Pathway Interactions (cont'd)**

| EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS | Y | N | U |
|---|---|---|---|
| **Are hazardous substances present or potentially present in sediments?**<br>**AND**<br>**Are ecologically important species or habitats present?**<br>**AND**<br>**Could hazardous substances reach these receptors via contact with sediments?** | <br><br>X<br><br>X | | X |
| When answering the above questions, consider the following:<br>• Known or suspected presence of hazardous substances in sediment.<br>• Ability of hazardous substances to leach or erode from surface soils and be carried into sediment via surface runoff.<br>• Potential for contaminated groundwater to upwell through, and deposit contaminants in, sediments.<br>• If sediments are present in an area that is only periodically inundated with water, terrestrial species may be dermally exposed during dry periods. Aquatic receptors may be directly exposed to sediments or may be exposed through osmotic exchange, respiration or ventilation of sediment pore waters.<br>• Terrestrial plants may be exposed to sediment in an area that is only periodically inundated with water.<br>• If sediments are present in an area that is only periodically inundated with water, terrestrial species may have direct access to sediments for the purposes of incidental ingestion. Aquatic receptors may regularly or incidentally ingest sediment while foraging. | | | |
| **Are hazardous substances present or potentially present in prey or food items of ecologically important receptors?**<br>**AND**<br>**Are ecologically important species or habitats present?** Salmonids<br>**AND**<br>**ould hazardous substances reach these receptors via consumption of food items?** | <br><br><br>X | | X<br><br><br><br>X |
| When answering the above questions, consider the following:<br>• Higher trophic level terrestrial and aquatic consumers and predators may be exposed through consumption of contaminated food sources.<br>• In general, organic contaminants with log $K_{ow} > 3.5$ may accumulate in terrestrial mammals and those with a log $K_{ow} > 5$ may accumulate in aquatic vertebrates. | | | |

**"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")**

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Bluebird

## Evaluation of Receptor-Pathway Interactions (cont'd)

| EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS | Y | N | U |
|---|---|---|---|
| **Are hazardous substances present or potentially present in surficial soils?**<br>**AND**<br>**Are ecologically important species or habitats present?**<br>**AND**<br>**Could hazardous substances reach these receptors via incidental ingestion of or dermal contact with surficial soils?** | X<br><br><br>X | <br>X | |
| When answering the above questions, consider the following:<br>• Known or suspected presence of hazardous substances in surficial (~1m depth) soils.<br>• Ability of hazardous substances to migrate to surficial soils.<br>• Significant exposure via dermal contact would generally ~~be limited to organic contaminants which are lipophilic and can cross epidermal barriers~~.<br>• Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces by rain striking contaminated soils (i.e., rain splash).<br>• Contaminants in bulk soil may partition into soil solution, making them available to roots.<br>• Incidental ingestion of contaminated soil could occur while animals grub for food resident in the soil, feed on plant matter covered with contaminated soil or while grooming themselves clean of soil. | | | |
| **Are hazardous substances present or potentially present in soils?**<br>**AND**<br>**Are ecologically important species or habitats present?**<br>**AND**<br>**Could hazardous substances reach these receptors via vapors or fugitive dust carried in surface air or confined in burrows?** | X<br><br><br>X | <br>X | |
| When answering the above questions, consider the following:<br>• V~~olatility of the hazardous substance (volatile~~ chemicals generally have Henry's Law constant > $10^{-5}$ atm-m$^3$/mol and molecular weight < 200 g/mol).<br>• Exposure via inhalation is most important to organisms that burrow in contaminated soils, given the limited amounts of air present to ~~dilute vapors~~ and an absence of air movement to disperse gases.<br>• Exposure via inhalation of fugitive dust is particularly applicable to ground-dwelling species that could be exposed to dust disturbed by their foraging or burrowing activities or by wind movement.<br>• Foliar uptake of organic vapors would be limited to those contaminants with relatively high vapor pressures.<br>• Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces. | | | |

**"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")**

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**Attachment B: Risk Based Screening Concentrations**
**Streamlined Ecological Risk Assessment**
**Bluebird Mine Site**

| Table B-1. Ecological Risk Based Screening Concentrations for Surface Water and Sediment at the Bluebird Mine | | | |
|---|---|---|---|
| *Chemical* | *Surface Water RBSC (µg/L)* [a] | *Sediment RBSC (mg/kg)* | *Source* |
| Aluminum | 87 | 58,000 | c |
| Antimony | 1,000 | 3 | a |
| Arsenic III | 150 | 35.3 | b |
| Barium | 23.3 (b) | 165 | c |
| Beryllium | 5.3 | 2 | d |
| Cadmium | 2.2 | 0.6 | a |
| Calcium | 116,000 | NA | NA |
| Chromium | 11 | 37 | a |
| Cobalt | 23 | 27 | e |
| Copper | 9 | 36 | a |
| Iron | 1,000 | 34,400 | b |
| Lead | 2.5 | 35 | a |
| Magnesium | 82,000 | NA | NA |
| Manganese | 120 | 1,100 | a |
| Mercury | 0.77 | 0.2 | a |
| Nickel | 52 | 18 | a |
| Potassium | 53,000 | NA | NA |
| Selenium | 5 | 4 | f |
| Silver | 0.12 | 4.5 | a |
| Sodium | 680,000 | NA | NA |
| Thallium | 40 | 8 | d |
| Vanadium | 20 | 64 | b |
| Zinc | 120 | 123 | a |

a - ODEQ Level II Ecological Screening Level Values except for barium.
b - Based on mean + 2 standard deviations of background concentrations in Clear Creek upstream of Blackjack.
c - Ingersoll, et al. (1996)
d - Efroymson, et al. (1997)
e - Friday (1998)
f - Van Derver and Canton (1997), Lemley and Smith (1987)
NA - Not Applicable.

| Table B-2. Ecological Risk Based Screening Concentrations for Soils/Wastes at the Bluebird Mine (mg/kg) [a] | | | | |
|---|---|---|---|---|
| *Chemical* | *Plants* | *Invertebrates* | *Birds* | *Mammals* |
| Aluminum | 50 | 600 | 450 | 107 |
| Antimony | 5 | 78 (b) | NA | 15 |
| Arsenic III | 10 | 60 | 10 | 29 |
| Barium | 500 | 3,000 | 85 | 638 |
| Beryllium | 10 | NA | NA | 83 |
| Cadmium | 4 | 20 | 6 | 125 |
| Chromium | 12.5 (c) | 12.5 (c) | 12.5 (c) | 340,000 |
| Cobalt | 20 | 1,000 | 190 (b) | 150 |
| Copper | 100 | 52.6 (c) | 190 | 390 |
| Iron | 35,300 (c) | 35,300 (c) | NA | NA |
| Lead | 50 | 500 | 16 | 4,000 |
| Manganese | 1,502 (c) | 1,502 (c) | 4,125 | 11,000 |
| Mercury | 0.3 | 0.1 | 1.5 | 73 |
| Nickel | 39.5 (c) | 200 | 320 | 625 |
| Selenium | 1.9 (c) | 70 | 2 | 25 |
| Silver | 2 | 50 | NA | NA |
| Thallium | 1.5 (c) | NA | NA | 1.5 (c) |
| Vanadium | 38.5 (c) | NA | 47 | 38.5 (c) |
| Zinc | 50 | 200 | 60 | 20,000 |
| a - ODEQ Level II Ecological Screening Level Values<br>b - USEPA (2003)<br>c - Based on maximum of 2 local soil background samples. | | | | |

**References:**


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Ingersol, C.G., Haverland, P.S., Brunson, E.L., Canfield, T.J., Dwyer, F.J., Henke, C.E., Kemble, N.E., Mount, D.R., and Fox, R.G. 1996. Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod *Hyalella azteca* and the Midge *Chironomus riparius*. National Biological Service Final Report for the USEPA Great Lakes National Program Office (GLNPO) Assessment and Remediation of Contaminated Sediment (ARCS) Project. EPA 905-R96-008. USEPA, Chicago.

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U.S. Environmental Protection Agency. 2003. Guidance for Developing Ecological Soils Screening Levels. OSWER Directive 9285.7-55, Office of Solid Waste and Emergency Response.

Van Derveer, W.D., and Canton., S.P. 1997. Selenium Sediment Toxicity Thresholds and Derivation of Water Quality Criteria for Freshwater Biota of Western Streams. Environmental Toxicology and Chemistry. 16:1260-1268.

## Appendix B: Site Photos

## Bluebird Mine Site


Bluebird pipeline route.


South waste rock pile.


Bluebird portal.


East of north waste rock pile showing end of track supports.

View of north waste rock pile showing remains of timber track supports.


Old pipeline toward mill site area.


Mill site sample location.


Outside edge of burned mill site structure.


Former uncontrolled AMD drainage area.


Former AMD drainage area showing oxidized and reduced zones.

Mill site sample location.

Vegetation in south end of Bluebird settling pond.

Redboy minewater entering road culvert to Forest Service land.

Bluebird settling pond downstream of discharge pipe.


Bluebird discharge pipe.


Downstream end of Bluebird settling pond.

Bluebird mine site across Clear Creek.

Gully formed by uncontrolled AMD discharge.


Portion of north waste rock pile.


Portion of north waste rock area.

North end of Bluebird settling pond adjacent to private property (note seepage on other side).

Vegetation at north end of Bluebird settling pond.


View looking at former mill site area.


Natural revegetation of iron-stained soils.

Clear Creek at downstream edge of Bluebird site.

# Appendix C:  Summary Data Tables
# From 2004 Sampling
# Bluebird Mine Site

Bluebird Waste Supplemental Data

| | BLU-WA-001 | Qual | BLU-WA-002 | Qual | BLU-WA-003 | Qual | ODEQ Level II Screening Values for Surface Soil | | | | EPA Ecological Soil Screening Levels | | | | EPA Region 9 PRGs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Plants** | **Inverts** | **Birds** | **Mammals** | **Plants** | **Inverts** | **Birds** | **Mammals** | |
| Aluminum | 5360 | | 4980 | | 1830 | | 50 | 600 | 450 | 107 | | | | | 100000 |
| Antimony | 0.53 | | 0.33 | | 45.5 | | 5 | | | 15 | | 78 | | 0.29 | 410 |
| Arsenic III | 34.6 | | 13.8 | | 165 | | 10 | 60 | 10 | 29 | | | | | 1.6 |
| Barium | 98.1 | | 75.4 | | 135 | | 500 | 3000 | 85 | 638 | | 330 | | 1000 | |
| Beryllium | 0.2 | U | 0.2 | U | 0.2 | U | 10 | | | 83 | | 40 | | 36 | 1900 |
| Cadmium | 0.2 | U | 0.2 | U | 0.45 | | 4 | 20 | 120 | 3500 | 32 | 140 | 1 | 0.38 | 450 |
| Calcium | 129 | | 173 | | 32.3 | | | | | | | | | | |
| Chromium | 55.6 | | 80.4 | | 102 | | 1 | 0.4 | 4 | 340000 | | | | | 64 |
| Cobalt | 3.38 | | 5.84 | | 1.68 | | 20 | 1000 | | 150 | 13 | | 190 | 240 | 1900 |
| Copper | 37.5 | | 52.3 | | 26.4 | | 100 | 50 | 190 | 390 | | | | | 41000 |
| Iron | 20400 | | 23500 | | 15900 | | 10 | 200 | | | | | | | 100000 |
| Lead | 81 | | 157 | | 129 | | 50 | 500 | 16 | 4000 | 110 | 1700 | 16 | 59 | 800 |
| Magnesium | 2240 | | 1930 | | 132 | | | | | | | | | | |
| Manganese | 284 | | 288 | | 72.7 | | 500 | 100 | 4125 | 11000 | | | | | 19000 |
| Mercury | 0.538 | | 0.395 | | 82 | | 0.3 | 0.1 | 1.5 | 73 | | | | | 310 |
| Nickel | 11 | | 18.1 | | 7.5 | | 30 | 200 | 320 | 625 | | | | | 20000 |
| Potassium | 2240 | | 1640 | | 1740 | | | | | | | | | | |
| Selenium | 0.75 | | 0.74 | | 13.9 | | 1 | 70 | 2 | 25 | | | | | 5100 |
| Silver | 0.5 | U | 0.5 | U | 53.4 | | 2 | 50 | | | | | | | 5100 |
| Sodium | 52 | | 50 | U | 50 | U | | | | | | | | | |
| Thallium | 0.1 | U | 0.1 | U | 0.1 | U | 1 | | | 1 | | | | | 67 |
| Vanadium | 20 | | 22.6 | | 4.02 | | 2 | | 47 | 25 | | | | | 1000 |
| Zinc | 41.4 | | 51.8 | | 45.6 | | 50 | 200 | 60 | 20000 | | | | | 100000 |

All values in mg/kg

Bluebird Waste Supplemental Data

General Chemistry

| Parameter | Units | Value | | |
|---|---|---|---|---|
| | | BLU-WA-001 | BLU-WA-002 | BLU-WA-003 |
| Acid-Base Potential | TCaCO3/1000T | -1.25 | -0.94 | -5.31 |
| Acid Generating | TCaCO3/1000T | 1.25 | 0.94 | 5.31 |
| Acid Neutralizing | TCaCO3/1000T | <0.30 | <0.30 | <0.30 |
| Non-Ext Sulfur | % | <0.010 | <0.010 | <0.010 |
| Pyritic Sulfur | % | 0.040 | 0.030 | 0.170 |
| Sulfate Sulfur | % | 0.080 | 0.060 | 0.160 |
| Total Sulfur | % | 0.120 | 0.090 | 0.330 |
| pH-paste | s.u. | 4.74 | 4.64 | 4.80 |

Bluebird Water Supplemental Data

| | | | Ecological Risk Screening Criteria | | | | | | | Human Health Risk Screening Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BLU-SW-001 | Qual | ODEQ Water Quality Criteria, Protection of Aquatic Life, Fresh chronic | ODEQ Level II Screening Values for Surface Water | | | EPA Ambient WCC Freshwater Aquatic Organisms, Chronic | EPA Ambient WCC Freshwater Aquatic Organisms, Chronic, Tier II | ORNL PRGs | ODEQ Consumption of Water and Fish | ODEQ Consumption of Fish Only | EPA WCC Consumption of Water and Organism | EPA WCC Consumption of Organism only |
| | | | | Aquatic | Birds | Mammals | | | | | | | |
| Aluminum | 251 | | 87 | 87 | 797000 | 8000 | | 87 | 87 | | | | |
| Antimony | 0.04 | | 1600 | 1600 | | 1000 | | | 30 | 146 | 45000 | 5.6 | 640 |
| Arsenic III | 1.8 | | 150 | 150 | 18000 | 6000 | 150 | | 0.31 | 0.018 | 0.14 | 0.018 | 0.14 |
| Barium | 9.1 | | | 4 | 150000 | 39000 | | | 4 | 1000 | | | |
| Beryllium | 0.07 | | 5.3 | 5.3 | | 5000 | | | 0.66 | 0.0000068 | 0.000117 | | |
| Cadmium | 0.79 | | | 2.2 | 10000 | 8000 | 0.25 | | 1.1 | 10 | | | |
| Calcium | 4371 | | | 116000 | | | | | | | | | |
| Chromium | 3 | | 11 | 11 | 7200 | 25000 | 11 | | 11 | 50 | 3433000 | | |
| Cobalt | 32.2 | | | 23 | | 9000 | | | 23 | | | | |
| Copper | 3.7 | | 12 | 9 | 341000 | 53000 | 9 | | 12 | 1300 | | 1300 | |
| Iron | 16293 | | 1000 | 1000 | | | | 1000 | 1000 | 300 | | | |
| Lead | 0.06 | | 3.2 | 2.5 | 28000 | 323000 | 2.5 | | 3.2 | | | | |
| Magnesium | 11151 | | | 82000 | | | | | | | | | |
| Manganese | 5052 | | | 120 | 7242000 | 676000 | | | 120 | 50 | 100 | | |
| Mercury | 0.04 | | 0.012 | 0.77 | 3300 | 1000 | 0.77 | | 1.3 | 0.000144 | 0.000146 | | 0.3 |
| Nickel | 102 | | 160 | 52 | 562000 | 38000 | 52 | | 160 | 13.4 | 100 | 610 | 4600 |
| Potassium | 1116 | | | 53000 | | | | | | | | | |
| Selenium | 0.4 | | 5 | 5 | 3600 | 1500 | 5 | | 0.39 | 170 | 4200 | 170 | 4200 |
| Silver | 0.009 | | 0.1 | 0.12 | | | | | 0.36 | 10 | | | |
| Sodium | 2797 | | | 680000 | | | | | | | | | |
| Thallium | 0.483 | | 40 | 40 | | 60 | | | 9 | 13 | 48 | 1.7 | 6.3 |
| Vanadium | 5 | | | 20 | 82000 | 1600 | | | 20 | | | | |
| Zinc | 201 | | 110 | 120 | 105000 | 1230000 | 120 | | 110 | 7400 | 26000 | | |

All values in µg/L

Bluebird Water Supplemental Data Additional Parameters

| Sample ID | | **BLU-SW-001** |
|---|---|---|
| Date Collected | | 9/10/2004 |
| Parameter | Units | |
| **General Chemistry** | | |
| Acidity | mg/L | 48 |
| Alkalinity | mg/L | 5 |
| Chloride | mg/L | 0.6 |
| Sulfate | mg/L | 61.4 |
| Total Dissolved Solids | mg/L | 132 |
| Total Suspended Solids | mg/L | 16 |
| **Field Measurements** | | |
| Temperature | °C | 11.4 |
| pH | s.u. | 5.13 |
| Conductivity | µS/cm | 157 |
| Total Dissolved Solids | ppm | 78.5 |
| Oxidation-Reduction Potential | mV | 118 |

**Bluebird 2004 Data Summary - TCLP Extractions**

| Sample ID | | BLU-WA-001 | | BLU-WA-002 | | EPA Reg. | OR Reg. |
|---|---|---|---|---|---|---|---|
| Date Collected | | 9/9/2004 | | 9/9/2004 | | Limit | Limit |
| Parameter | Units | | Qual | | Qual | | |
| **Metals** | | | | | | | |
| Aluminum | mg/L | 0.543 | | 0.194 | | | |
| Antimony | mg/L | 0.0030 | U | 0.0030 | U | | |
| Arsenic | mg/L | 0.0030 | U | 0.0030 | U | 5 | 0.004 |
| Barium | mg/L | 0.284 | | 0.210 | | 100 | 100 |
| Beryllium | mg/L | 0.0020 | U | 0.0020 | U | | 0.002 |
| Cadmium | mg/L | 0.0020 | U | 0.0020 | U | 1 | 0.5 |
| Calcium | mg/L | 1.80 | | 1.57 | | | |
| Chromium | mg/L | 0.0109 | | 0.0081 | | 5 | 10 |
| Cobalt | mg/L | 0.0071 | | 0.0356 | | | |
| Copper | mg/L | 0.0251 | | 0.0064 | | | 100 |
| Iron | mg/L | 0.979 | | 0.603 | | | |
| Lead | mg/L | 1.29 | | 2.66 | | 5 | 2 |
| Magnesium | mg/L | 1.19 | | 1.42 | | | |
| Manganese | mg/L | 0.776 | | 1.71 | | | 400 |
| Nickel | mg/L | 0.018 | | 0.057 | | | |
| Potassium | mg/L | 6.3 | | 6.6 | | | |
| Selenium | mg/L | 0.0030 | U | 0.0030 | U | 1 | |
| Silver | mg/L | 0.0050 | U | 0.0050 | U | 5 | 5 |
| Thallium | mg/L | 0.0020 | U | 0.0020 | U | | |
| Total Mercury | mg/L | 0.00020 | U | 0.00020 | U | 0.2 | 0.2 |
| Vanadium | mg/L | 0.0050 | U | 0.0050 | U | | |
| Zinc | mg/L | 0.0656 | | 0.0846 | | | |

U - Detection Limit

**Bluebird 2004 Data Summary - SPLP Extractions**

| Sample ID | | **BLU-WA-001** | | **BLU-WA-002** | | **EPA Reg.** | **OR Reg.** |
|---|---|---|---|---|---|---|---|
| Date Collected | | 9/9/2004 | | 9/9/2004 | | **Limit** | **Limit** |
| Parameter | Units | | Qual | | Qual | | |
| **Metals** | | | | | | | |
| Aluminum | mg/L | 0.020 | U | 0.022 | | | |
| Antimony | mg/L | 0.0030 | U | 0.0030 | U | | |
| Arsenic | mg/L | 0.0030 | U | 0.0030 | U | 5 | 0.004 |
| Barium | mg/L | 0.0241 | | 0.0729 | | 100 | 100 |
| Beryllium | mg/L | 0.0020 | U | 0.0020 | U | | 0.002 |
| Cadmium | mg/L | 0.0020 | U | 0.0020 | U | 1 | 0.5 |
| Calcium | mg/L | 0.45 | | 1.26 | | | |
| Chromium | mg/L | 0.0060 | U | 0.0060 | U | 5 | 10 |
| Cobalt | mg/L | 0.0060 | U | 0.0166 | | | |
| Copper | mg/L | 0.0030 | U | 0.0030 | U | | 100 |
| Iron | mg/L | 0.057 | | 0.377 | | | |
| Lead | mg/L | 0.0030 | U | 0.0840 | | 5 | 2 |
| Magnesium | mg/L | 0.318 | | 0.581 | | | |
| Manganese | mg/L | 0.194 | | 0.914 | | | 400 |
| Nickel | mg/L | 0.010 | U | 0.029 | | | |
| Potassium | mg/L | 2.4 | | 2.5 | | | |
| Selenium | mg/L | 0.0030 | U | 0.0030 | U | 1 | |
| Silver | mg/L | 0.0050 | U | 0.0050 | U | 5 | 5 |
| Sodium | mg/L | 2.91 | | 2.47 | | | |
| Thallium | mg/L | 0.0020 | U | 0.0020 | U | 0.2 | 0.2 |
| Total Mercury | mg/L | 0.00020 | U | 0.00020 | U | | |
| Vanadium | mg/L | 0.0050 | U | 0.0050 | U | | |
| Zinc | mg/L | 0.0051 | | 0.0299 | | | |
| pH | s.u. | 7.08 | | 6.8 | | | |

U - Detection Limit