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
Umatilla National Forest
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LIST OF ACRONYMS

ABA	Acid Base Accounting
AMD	Acid mine drainage
APA	Abbreviated Preliminary Assessment
ASL	Above sea level
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
EA	EA Engineering, Science, and Technology, Inc.
EE/CA	Engineering Evaluation/Cost Analysis
EIS	Environmental Impact Statement
ER-L	Effects Range-Low
ft/s	Feet per second
FS	Forest Service
NF	National Forest
NOAA	National Oceanic and Atmospheric Administration
NVCS	National Vegetation Classification Standards
NWI	National Wetlands Inventory
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ONHIC	Oregon Natural Heritage Information Center
OSC	On-Scene Coordinator
OWRD	Oregon Water Resources Department database
PEL	Probable Effects Level
PRG	Preliminary Remediation Goal
PVC	Polyvinyl chloride
S&M	Survey and Manage
SARA	Superfund Amendments and Reauthorization Act
SI	Site Inspection
SOC	Species of Concern
SAP	Sampling and Analysis Plan
SPLP	Synthetic Precipitation Leachate Procedure
T&E	Threatened and Endangered
TAL	Target Analyte List
TDL	Target distance limit
TDS	Total dissolved solids
TEL	Threshold Effects Level
TMS	Timed Meander Search
TOC	Total Organic Carbon
TSS	Total suspended solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WP	Work Plan
XRF	X-Ray Fluorescence
YOY	Young-of-Year

EXECUTIVE SUMMARY

A Site Inspection (SI) was performed at the Bluebird Mine and Blackjack Mine sites, located in the Umatilla National Forest (NF), near Granite, Oregon. The SI was performed to determine if wastes at the sites pose an immediate or potential threat to human health and the environment, and to collect information to support a decision regarding the need for further action.

The abandoned mine sites are located within one mile from one another adjacent to Clear Creek, which is located within the Granite Creek watershed. The Blackjack Mine, the upstream site, is on the west side of Clear Creek. The site consists of 2 adits, one settling pond (dry when samples were collected), and one large and 2 small waste piles. Water from the upper adit drains through a pipe and discharges to a narrow settling pond on the east side of Clear Creek. There is evidence that the upper adit has discharged Acid Mine Drainage (AMD) directly into the creek. AMD from the lower adit forms a marshy area, then drains into the creek. An accidental spill occurred at the site shortly after the initial field sampling event took place in July. In August, 10 days after the spill, four of the original creek sampling locations were re-sampled to evaluate impacts from the spill.

The Bluebird mine site is on the east side of Clear Creek and consists of one adit, one retention pond, one large and 2 small waste piles, and what appeared to be a former mill area. The adit drains via a pipe to a pond constructed from dredge tailings on the west side of Clear Creek. There is evidence that AMD has also drained directly from the mine into the creek.

Tasks performed during the SI included background research and file review, onsite and offsite reconnaissance, and collection and analysis of soil, waste rock material, surface water, pore water, sediment, plant tissue, and benthic macroinvertebrate samples. Field activities were performed during July 2003 followed by the spill resampling in August. Results of the SI indicated the following:

- A number of metals were detected at levels above available screening criteria in surface water samples collected from the adit discharges and settling ponds at both sites.

- Numerous metals were detected at levels above applicable screening criteria in surface and subsurface soil and waste material at the sites; many of these metals also exceeded the concentrations detected in background soil samples.

- After the Blackjack spill, a large arial extent of flocculent iron precipitate was observed at the first downstream sample location. In addition, the biological results suggest localized impacts to the benthic community occurred in the pool habitat at this location. These impacts were not observed at the sample locations further downstream on Clear Creek.

- One of the fish species observed in Clear Creek during the SI and after the spill are thought to be either inland/interior redband trout or westslope cutthroat trout. These species are both federal-listed SOC and identified as a vulnerable species by the Oregon Fish and Wildlife Commission. These fish may be impacted by mine discharges.

Based on the results of the SI, performance of an Engineering Evaluation/Cost Analysis (EE/CA) is recommended at the Bluebird Mine and Blackjack Mine sites. As part of the EE/CA, a risk evaluation should be performed to assess the human and ecological impacts, establish site removal cleanup standards, and evaluate remediation technologies.

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc. (EA) performed a site inspection (SI) for the U.S. Department of Agriculture, Forest Service (Forest Service) at the Bluebird and Blackjack Mine sites, located in the Umatilla NF near Granite, Oregon. The work was performed under Contract Number 10181-1-D010, Delivery Order R6-14-03-16. The SI was performed in general accordance with U.S. Environmental Protection Agency (USEPA) guidance for performing Site Inspections under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The objectives of the SI were to (1) assess the immediate or potential threat that wastes at the site pose to human health and the environment, and (2) to collect information to support a decision regarding the need for further action under CERCLA and the Superfund Amendments and Reauthorization Act (SARA). Potential contaminant sources identified at the abandoned Bluebird and Blackjack Mine sites included waste rock and AMD.

Tasks performed during the SI included background research and file review, onsite and offsite reconnaissance, and collection and analysis of soil, waste, surface water, pore water, sediment, plant tissue, and benthic macroinvertebrate samples. Field work for the SI was performed at the Bluebird Mine from 20 to 21 July and at the Blackjack Mine from 22 to 23 July, 2003. Following a spill from the pipe draining the upper adit, re-sampling at 4 of the stream stations at the Blackjack was performed from 8 to 10 August, 2003 (10 days after the spill occurred). The SI was performed in accordance with the project plans including the Work Plan and Sampling and Analysis Plan (EA 2003a), Health and Safety Plan (EA 2003b), and Standard Operating Procedures (EA 2003c). A number of modifications to the sampling locations and techniques were made in the field, based on site observations and field conditions, and with concurrence of the Forest Service On-Scene Coordinator (OSC). These modifications are documented in Appendix A. This report is organized into the following sections:

- Descriptions of the sites, their operational history, and wastes generated are provided in Section 2.
- The results of the SI, along with discussions of the groundwater, surface water, soil, and air exposure pathways, are provided in Section 3.
- A summary and conclusions are provided in Section 4.
- The appendixes include the following: a list of deviations from the project plans (Appendix A), site photographs (Appendix B), a General Information Form for each site (Appendix C), copies of supporting information (Appendix D), a detailed wetlands description (Appendix E), aquatic survey results summary tables (Appendix F), analytical data summary tables (Appendix G), waste pile calculations (Appendix H), soil sample descriptions (Appendix I), laboratory analytical reports (Appendix J), and a quality assurance/quality control summary (Appendix K).

2. SITE DESCRIPTION, OPERATIONAL HISTORY, AND WASTE CHARACTERISTICS

2.1 DESCRIPTION AND LOCATION

The locations of the Bluebird and Blackjack Mines are shown on Plate 1. Bluebird Mine is accessed from Forest Service (FS) Road 10 and Blackjack Mine from FS Road 13. Accessing the sites requires crossing Clear Creek on foot, as there are no bridges crossing the creek to either site. In 1999, the Forest Service road was moved from the west to the east side of Clear Creek and a major salmon habitat restoration project was conducted in the area of the 2 mines along the creek (Visconty 2003). Waste pile volumes were calculated by Anderson Perry and Associates, Inc, La Grande, Oregon. Refer to Appendix H for details.

Bluebird Mine

The Bluebird Mine is located approximately 2.7 mi southwest of the town of Granite (arial distance), in Grant County, Oregon. The site is situated on moderate to steep hillsides adjacent to Clear Creek within the Granite Mining District. The site location is included on the Granite Quadrangle U.S. Geological Survey (USGS) 7.5-minute topographic map. The location description for the site is:

- Latitude 44° 45’ 59”N
- Longitude 118° 29’ 37”W
- Section 11, Township 9 South, Range 35 East.

The site is currently inactive. The site covers an area of approximately 2 acres on moderate to steep hillsides. Maps showing existing site features are presented as Figures 1a and 1b, the northern and southern portions of the site (respectively). The site generally consists of the following:

- One adit, which is currently sealed off with a bulkhead. A second adit, approximately 50 ft higher in elevation, is collapsed. The sealed adit is located approximately 50 vertical ft above the elevation of Clear Creek. Water is drained from the adit via an 8-in. polyvinyl chloride (PVC) pipe, which goes underneath Clear Creek and discharges to a pond on the opposite side of Clear Creek. The pond eventually drains into the flood zone of Clear Creek.

- A moderate-sized settling pond (dry at the time of the SI investigation), which encompasses approximately 60 by 15 ft. The pond is lined with approximately 6 in. of red and orange silty “sludge.”

- One large and 2 small waste piles. One small waste pile (9 cy ^{3}) is located at the southern end of the settling pond. The other small waste pile (350 cy ^{3}) is located on moderate slopes and in the floodplain of Clear Creek. The large waste pile (2,238 cy ^{3}) is situated on steep slopes just below the adit and split in two on either side of the portal.

- An area containing wood debris that appears to be the location of the former mill. The 10-stamp mill reportedly processed material in a cyanide vat system, used for the lower-grade ore, and when the higher-grade ore was discovered, a gravity flotation circuit was used (Boles 2003).

The adit at one time discharged AMD though a deep channel directly to Clear Creek. Prior to the 1980s, the drainage channel was diverted to the north immediately upgradient of the creek to drain AMD to the settling pond. The channel contains iron staining and appears to periodically overflow directly to the

creek, as staining was observed in a straight-line path from the portal to the creek. The velocity of AMD through the pipe was measured during the SI, however the calculated flow does not appear to be correct, possibly due to blockages in the pipe.

In approximately 1988, the Forest Service installed a bulkhead at the portal entrance and a discharge pipe which diverts AMD underground in an upstream direction (south) to a pond located on the west side of Clear Creek and FS Road 10. The settling pond was formed out of the existing dredge tailings from the 1950s (Visconty 2003).

There is no file on the construction of the current discharge system. The bulkhead in the portal was reportedly constructed out of pressure treated wood, visqueen and sand, and the portal was backfilled. The discharge pipe was installed at the base of the bulkhead. The system discharges to a pond, which is located on private land. It was reported that the system has not been functioning properly since it was installed. It has also been extremely difficult to clean out the pipe; consequently, overflows have occurred. One spill happened in 2001 due to a clog in the pipe. In 1999, when the Forest Service and Grant County moved FS Road 10 to run between Clear Creek and the ponds, they installed an 18-in. culvert to connect the drainpipe to the pond under the road. The drainpipe reportedly was never connected to the culvert but was left in-place to drain under the road to the pond (Visconty 2003).

Blackjack Mine

The Blackjack Mine is located approximately 3 mi southwest of the town of Granite (aerial distance), in Grant County, Oregon. The site is located adjacent to and on the west side of Clear Creek within the Granite Mining District. The site is included on the Granite Quadrangle USGS 7.5-minute topographic map. The location description for the site is:

- Latitude 44° 47’ 09”N
- Longitude 118° 27’ 59”W
- Section 14, Township 9 South, Range 35 East.

The site is currently inactive. The site covers an area of approximately 2 acres on steep hillsides. A map showing existing site features is presented as Figure 2. The site generally consists of the following:

- An upper adit and active settling pond. The upper adit is located approximately 90 vertical ft above Clear Creek. Water from the upper adit drains through a 6-in. PVC pipe that eventually discharges to a man-made settling pond (300 by 20 ft) formed by dredge tailings. The settling pond is located on the east side of Clear Creek and the road. From the adit, the pipe follows an abandoned road in a northwest direction and then turns north under the creek and road to its discharge outlet in the pond.

- Lower adit with a collapsed portal. The lower adit is located approximately 30 vertical ft above the elevation of Clear Creek. This adit drains directly to the surface and forms a marshy area adjacent to, and on the west side of, Clear Creek.

- Three small waste piles. The largest waste pile (68 cy^3) is situated near the upper adit. The second waste pile (9 cy^3) is located slightly upgradient of the adit and the third waste pile (12 cy^3) is situated near the lower adit. The volume calculation for the largest of these waste piles is suspect because of its geometry; therefore, its volume measurement should be considered an estimate.

- An inactive settling pond (dry at the time of sampling). This moderate-sized pond is located just south of the site, on the west side of and adjacent to, Clear Creek. Prior to the installation of the discharge pipe, AMD was drained into this settling pond via a 4-in. PVC pipe. AMD is now piped to the large settling pond on the east side of Clear Creek (described previously).

At the time of the SI field investigation, AMD was flowing from both adits. AMD discharge from the lower adit, located at 1,020 ft-above sea level (ASL), was measured at 2.33 gal per minute. During the field investigation, the field biologist attempted to measure the flow rate from the upper adit at 2 different pipe cleanouts, but was unable to collect a measurement safely (due to the large amount of flow through the pipe). It is also evident from the stained soils observed during the SI, that AMD has flowed through a channel directly downhill from the upper adit into the creek.

On 29 July 2003, Forest Service contractors were attempting to clean out the discharge pipe that drains from the upper adit to the pond. First, they attempted to unclog the lower portion of the pipe (using a 2-in. pipe cleaner), between the lower cleanout and the discharge point in the pond. Then they found another clog at the upper portal and attempted to clean out the pipe from the upper cleanout. Because of the pipe system's design, and the fact that the pipe was not fully cleaned out at the bottom, water backed up and spilled out of the upper cleanout. The water spilled out over the waste pile directly into Clear Creek. The personnel were unable to cap the upper cleanout (where the water was flowing from) and water continued to flow from the adit into the creek for approximately 24 hours. An estimated 70,000 gal of water flowed into the creek during that time period. An iron plume was observed approximately 1 mi downstream from where the water entered the creek. One week later, Forest Service personnel returned to finish cleaning out the pipe and reseal the cleanout (Visconty, 2003).

2.2 OPERATIONAL HISTORY AND WASTE CHARACTERISTICS

Mining in the Granite Creek area began as early as the 1860s and was a significant part of Oregon's mineral industry prior to World War II. Dredge mining was the primary form of mining in the region until the mineral production that could be achieved using hand-operated equipment began to decline. In the late 1880s, lode mining became the most profitable form of mining with the advent of large-scale drilling and crushing equipment and chemical extraction methods (to extract the gold from its alloys). In the 1920s, dredging for gold in the rivers again became profitable using large-scale dredging equipment. Numerous dredge tailings piles are still visible along these creeks (USDA 2002). There is evidence of extensive dredge mining along Clear Creek in the vicinity of the sites.

Bluebird Mine

Six lode claims were located for the Bluebird Mine between 1897 and 1899. They were the Bluebird, T.T., Diana, Little Rock, Cross Lode, and Sullivan No. 3 claims. Two mill sites also were located; one each on the Bluebird and T.T. claims (USFS 2003a).

The claims were recorded by E.J. Thorpe and two partners, and were maintained in the Grant County records as such until 1903, when the Bluebird Mining Company purchased all six of the claims. This transaction is the last chronicle of the Bluebird Mine in the county files, and there is no indication of whom the owners or officers of the Bluebird Mining Company were. Interestingly, a prospectus issued in 1902 for the Bluebird Mining Company lists E.J. Thorpe as president and G.H. Wheeler as treasurer. It also indicated that Wheeler and Company, Bankers of New York, were the financiers of the Bluebird Mining Co (USFS 2003a).

According to historical mining publications and newspaper articles, development at the mine was moderate, but production was minimal. Total development consists of approximately 2,500 feet of workings on two levels, including several shafts of unknown depth and several open cuts. It was reported that the upper level consisted of a 900-ft tunnel (in 1905) with several shafts (Boles 2003). It was also indicated that a cyanide mill on the T.T. claim was used until higher-grade vein material was discovered. A gravity flotation circuit was then installed in the mill. No production records are known to exist; however 1,500 tons of ore, worth $5,000, were removed from the mine between 1904 and 1905. This is according to a 1916 interview with a local miner by the Oregon Bureau of Mines and Geology (USFS 2003a).

In 1931 the widow of T.J. Sheedy, Katie Sheedy, and two partners filed on the Cleveland claim, formerly known as the Bluebird claim and now abandoned. There are no records documenting the ownership of the mine by T.J. Sheedy, however Mrs. Sheedy maintained this claim until 1938 when the Blue Mountain Gold Dredge Company began to file affidavits of assessment on her behalf. Either Mrs. Sheedy or the Blue Mountain Gold Dredge Company filed affidavits regularly until 1950. Mrs. Sheedy's affidavits indicate that during her ownership only tunnel clearing and re-timbering activities occurred. The affidavits filed by the Blue Mountain Gold Dredge Company are not specific about what they did to improve the claims with most indicating that a watchman was maintained at the site. After 1950, there are no records of this mine on file with any agency, nor is it discussed in any historical documents (USFS 2003a).

The following is a list of the known historic owners or operators of the Bluebird Mine:

1. 1897-1903, Ezra J. Thorpe, Ellen A. Thorpe, R.L. Hale – locators/owners,
2. 1903-1905?, Bluebird Mining Company – owners by purchase,
3. 1931-1950, Katie Sheedy, Henry Cavin, A.K. (Pat) Glenn – locators/owners,
4. 1938, A.E. Murray, president of Blue Mountain Gold Dredge Co. – operator?
5. 1938-1950, R.R. Porter, president of Blue Mountain Gold Dredge Co. – operator?

Blackjack Mine

Between 1898 and 1903, T.J. Sheedy and various partners located seven claims on the Blackjack site: Blackjack, Senator, Constitution, Grey Rock, Osceola, Congress, and Trade Dollars. In 1903, the mine was sold to the Blackjack Gold Mining Company and four more claims were located to fill in gaps between the original seven. They were Flaherty, Roosevelt, Calamut, and Sheedy. T.J. Sheedy was listed as the superintendent of the mine for the Blackjack Gold Mining Company (USFS 2003a).

According to historical mining publications and newspaper articles, development at the site, which occurred until 1906, was moderate. Records indicate that no production ever occurred. Total development consists of approximately 3,000 feet of workings, including crosscuts and raises, all on one level. A lower portal is also located on the Grey Rock claim, but is not physically connected to the main Blackjack tunnel. It was supposedly developed to work the Senator vein, but there is no indication this vein was reached and development records were not found (USFS 2003a).

T.J. Sheedy located the National claim in 1915, formerly known as the abandoned Blackjack Mine and was abandoned. The affidavit stated the location included the tunnel and all buildings formerly claimed by the Blackjack Gold Mining Company. Between 1915 and 1929, T.J. Sheedy and a partner located the Congress, Banner, Gold Coin, and Washington claims, and maintained the Blackjack Mine until his death sometime between 1929 and 1936. Sheedy's widow, Katie Sheedy, took over maintenance of these claims in 1936 along with various partners. In 1943, the Blue Mountain Gold Dredge Company began

filing affidavits on her behalf, and either the company or Mrs. Sheedy filed them steadily until 1950. Records filed by the company indicate the only activity was maintaining a watchman at the site, which was reportedly shut down in order to support World War II activities. No records of this mine are on file with any agency, or discussed in any historical document, after 1950 (USFS 2003a).

The following is a list of known historic owners and operators of the Blackjack Mine:

1. 1898-1929, Timothy J. Sheedy - locator/owner,
2. 1903, Maggie Sheedy – owner,
3. 1898-1907, Joseph Sheedy – locator/owner,
4. 1901, T.H. Murphy and John Monahau – locators/owners,
5. 1901, George Young – owner,
6. 1903-1904, Blackjack Gold Mining Company – owner by purchase (T.J. Sheedy listed as supt., M.B. Reese listed as agent)
7. 1919, T.W. Sheedy – locator/owner,
8. 1936-1950, Katie Sheedy – locator/owner,
9. 1939, Alfred Thode – operator,
10. 1938-1950, R.R. Porter, president of Blue Mountain Gold Dredge Co. – operator?
11. 1941, Clarence and Sue Merritt, Willis Wall – owners.

Mining waste reclamation associated with the Blackjack Mine was started by the Forest Service in the mid-1960s, with major work beginning in 1979. These activities included fish habitat restoration on Clear and Granite creeks. This was a cooperative venture with the Oregon Department of Fish and Wildlife, with the reduction of heavy metal concentrations one of the prime objectives (USFS 2003b). The following is a summary of these activities:

1. 1980-1991 - the Forest Service sampled 13 stations in Clear Creek for water quality purposes. Three of the stations were associated with Blackjack Mine.
2. 1981 - an outlet pipe with concrete plug was installed in the portal of the Blackjack Mine.
3. 1983 - the drainpipe and settling pond system at Blackjack Mine was constructed by the Forest Service in order to avoid direct mine discharge into Clear Creek.
4. 1984 - Forest Service file information indicates that the drainage system was not functioning properly due to a buildup of precipitated mine material in the pipe. As a result, excess water was spilling into Clear Creek. Solutions identified at the time were to clean out the pipe or divert water to another holding pond using a larger pipe. Remedial actions undertaken consisted of pipe cleanout and water quality sampling.
5. 1985-1998 - drainpipe maintenance and cleaning was performed annually.
6. 1987 - the drainpipe was extended 300 yards underground to a ½ mile long channel in the dredge tailings.
7. 1989 - wetland vegetation was transplanted for filtration purposes.
8. 1994 - the upper section of the drainpipe was replaced with a 6-inch diameter section.
9. 1995 - agents of the U.S. Bureau of Mines visited the site and collected samples at two locations.
10. 1997 - the EPA conducted a sampling investigation of the Granite Creek watershed that involved Blackjack Mine.
11. 1998-2003 - drainpipe maintenance and cleaning was conducted twice a year.
12. 1999 - an environmental assessment was conducted in lower Clear Creek of fish spawning and rearing habitat. It identified needed improvements in the drainpipe systems of Blackjack, Bluebird, and Red Boy Mines.
13. 2003 - a contract to design a replacement drainpipe system is underway.

Waste Characteristics

The types of mine waste problems are extensive, but the most difficult one to address is the AMD. AMD results from both surface and underground mine workings, waste and tailings piles, and settling ponds (Durkin, Herrmann 1994). Except for tailings, all are present at the Bluebird and Blackjack Mine.

In the presence of oxygen and water, the sulfide oxidizes to create what is commonly referred to as "yellow boy" (iron hydroxide), sulfate, and hydrogen ions. The release of hydrogen ions causes the water to become acidic. AMD is characterized by the presence of the following:

- Low pH and increased acidity
- Elevated heavy metal concentrations, sulfates, and total dissolved solids (TDS)

The low pH of the water causes the metals within the mine and waste rock to become soluble. The receiving environment is most harmed by the high metal concentrations in the water. (Durkin, Herrmann 1994)

2.3 PREVIOUS INVESTIGATIONS

Bluebird Mine

The USEPA performed SIs on 12 mine sites located within the Granite Creek Watershed in October 1996 (USEPA 1997a). Bluebird Mine was a part of this investigation. During the USEPA SI, sediment and surface water samples were collected from 4 locations consisting of the adit, the settling pond, and upstream and downstream locations on Clear Creek.

All the samples were analyzed for metals and evaluated against media-specific screening guidelines. Four sediment screening guidelines were used and consisted of the severe and low effect levels of the Ontario Sediment Quality Guidelines, and two sets of criteria based on Apparent Effects Thresholds developed by the USEPA. Surface water sample guidelines were based on the State of Oregon and USEPA ambient water quality criteria (USEPA 1997a).

In the sediment samples, 8 metals exceeded one or more of the guidelines, including arsenic, copper, chromium, and zinc. In the surface water samples, arsenic, cadmium, and zinc exceeded evaluation guidelines.

The Forest Service conducted an Abbreviated Preliminary Assessment (APA) of the Bluebird Mine in 2001. The APA was conducted to determine whether the potential exists for a release of hazardous contaminants to the environment, and to further characterize the site.

The Bluebird Mine APA included using a Niton 700 series X-Ray Fluorescence Spectrum Analyzer (XRF) to field analyze samples from the waste piles. The results indicated that arsenic, antimony, and iron exceeded USEPA Region 9 Preliminary Remediation Goals (PRGs).

No other type of sampling was conducted, but the APA also documented the existence of AMD flowing from the adit into a settling pond and the presence of waste piles within the floodplain of Clear Creek. Based on these findings, a decision was made to conduct a SI.

Blackjack Mine

The 1996 USEPA site inspection for the Granite Creek Watershed also included the Blackjack Mine. Six sample locations were selected and surface water and sediment samples collected at each of them. The locations were at the lower adit portal, in the settling ponds, and upstream and downstream locations on Clear Creek (USEPA 1997a).

The samples were also analyzed for metals, and the same screening guidelines as the Bluebird Mine were used. Twelve metals detected in the sediment samples exceeded at least one of the four guidelines, including arsenic, cyanide, copper, chromium, mercury, and selenium. In the surface water samples, 4 metals exceeded the guideline concentrations and consisted of cadmium, copper, lead, and zinc.

The Forest Service conducted an APA at Blackjack Mine in 2002 for the same reasons the APA was conducted at the Bluebird Mine in 2001. A visual inspection was conducted and no sampling or XRF screening was performed. AMD was observed flowing from the upper adit through the existing underground pipeline into a settling pond on the east side of Clear Creek. The lower adit was discharging AMD directly into Clear Creek. Based on these observations, it was recommended that a SI be conducted.

Environmental Impact Statement (2002)

In 2002, the Forest Service also conducted an Environmental Impact Statement (EIS) on Granite Area Mining Projects, including the Bluebird and Blackjack mines. The Columbia River bull trout and Mid-Columbia steelhead, both of which occur in the Granite Creek watershed, are listed as threatened under the Federal Endangered Species Act. In addition, several of the streams within the watershed are on the State of Oregon 303(d) list of impaired waters, as stipulated by the Clean Water Act. Given these facts, an EIS was necessary when the Forest Service proposed to approve Plans of Operation on 16 mining claims located within the watershed.

The EIS identified water quality and fish and aquatic habitat as two essential issues, and compared the effects of three alternatives on these issues. No sampling was conducted during the EIS, but the Clear Creek drainage was evaluated as a part of the larger watershed.

3. PATHWAY AND ENVIRONMENTAL HAZARD ASSESSMENT

3.1 GROUNDWATER PATHWAY

3.1.1 Geology

The Blackjack and Bluebird Mines are located within the Blue Mountains physiographic province. The Blue Mountains comprise a complex system of mountain ranges, high plateaus, deep canyons, and broad valleys. Approximately three fourths of the gold produced in Oregon has come from lode and placer deposits within the gold belt of the Blue Mountains area. The primary area of gold occurrence is approximately 50 mi wide and 100 mi long, extending from John Day on the west to the Snake River on the east (Brooks et. al. 1968). Most of the mining within this area took place in Grant and Baker Counties.

The gold belt of the Blue Mountains is divided into several areas, which are further divided into districts, based on the dominant intrusive bodies and their associated gold deposits. The Blackjack and Bluebird Mines are included in the northeastern part of the Greenhorn District of the Greenhorn Mountains area by some authors, and in the southwestern part of the Granite District of the Elkhorn Mountains area by others (Brooks et.al. 1968 and 1982). The site area includes a greater concentration of small veins than other areas of the Blue Mountains, leading to the development of numerous small mines and prospects.

Mineral deposits in the study area are generally characterized by Brooks, et.al. (1968) and Koch (1959) as follows:

- The lode deposits occur in pre-Tertiary rocks consisting of bedded metamorphic rocks with igneous intrusions. The bedded rocks originally consisted of a thick series of shales, with lesser amounts of limestones and sandstones, and are interbedded with lavas.

- The pre-Tertiary rocks have gone through intense structural deformation and metamorphism. Further metamorphism took place during intrusion of the igneous bodies.

- Most of the veins and mineralized shear zones appear to be genetically related to the intrusion of Jurassic-Cretaceous granitic rocks; they occur primarily near the contacts of the intrusives with older rocks.

- Most of the gold deposits occupy fissures in argillite or in the granodiorite intrusions.

- The lode gold production in the area has been from narrow, steeply dipping veins and mineralized shear zones developed mainly by underground workings.

The Blackjack and Bluebird Mines were developed in the Elkhorn Ridge Argillite. This is mainly a dark-colored argillite, siliceous argillite, and chert with small amounts of fine-grained felsic tuff, sandstone, and conglomerate. Some argillites are almost black due to high carbon content. Breciation of the chert and silicious argilite of the Elkhorn Ridge Argillite is especially notable in the Blackjack and Bluebird Mine area (Brooks, et. al. 1982). In places, the brecciated rocks are silicified and iron-oxide stained.

At the Bluebird Mine, the geology and mining activity are described by Brooks, et. al. (1982) as follows:

- The gold occurs in veins of crushed argillite, in which the broken rock is cemented by quartz seams typically showing a comb structure.
- Minor amounts of pyrite and arsenopyrite are present.
- Total development includes approximately 2,500-ft of crosscuts with short drifts.
- An estimated 250 oz of gold was produced from 1,500 tons of ore.

At the Blackjack Mine, the geology and mining activity are described by Brooks, et.al. (1982) as follows:

- The gold occurs in limonitic silicified shear zones in chert and argillite.
- Total development includes over 3,000 ft of workings.
- The past production from the mine is listed as "none."

3.1.2 Hydrogeology

No discussion or documentation of groundwater conditions at the site or in the site vicinity has been found. Shallow groundwater likely does not form a laterally continuous aquifer in the study area due to the presence of igneous intrusions and shallow bedrock. Water seeping from the mine adits may come from deeper groundwater entering the mines throughout the underground workings. Shallow groundwater in the site area likely flows into Clear Creek.

No groundwater samples were collected during the SI; however, water samples were collected from the discharges at both adits at the Blackjack Mine and from the one adit at the Bluebird Mine. Because these discharges impact local surface water quality, analytical results for these samples are discussed with the surface water samples in Section 3.2.5.

3.1.3 Groundwater Targets

The target distance for groundwater has been defined as a 4-mi radius from the sites (Plate 1). Potential receptors include drinking water wells and wellhead protection areas. Based on a search of the Oregon Water Resources Department database (OWRD) for water wells, 6 wells are located within a 4-mile radius of the sites (2003). There are no wellhead protection areas within a 4-mi radius of the site.

There are 2 wells nearest to the Blackjack Mine, located within 1 to 2 mi of the site. There was only information available for one of the wells. According to OWRD records, this well is located to the northwest of the site near several other mine sites and was installed in 1981. First water reportedly was encountered at a depth of 80 ft during drilling. The well was completed to a depth of 340 ft and the static water level, as measured upon well completion, was 9 ft. The well is used for domestic purposes (OWRD 2003).

The nearest wells to the Bluebird Mine are located within 0.5 to 1 mile from the site, both on the west side of Clear Creek. Because these wells are on the opposite side of Clear Creek from the mine, they likely would not be impacted by contaminants migrating from the site. The nearest wells located on the east side of the Creek are located in the town of Granite, at least 2.5 miles from the site.

3.1.4 Groundwater Pathway Summary

Based on the available information, no release of hazardous substances from either mine site to local groundwater systems is suspected. Considering the distance from the sites to the nearest wells, it is very unlikely that the wells could be impacted from groundwater coming from the sites. Therefore, the groundwater pathway appears to be incomplete. Groundwater that discharges from the adits may impact nearby surface water bodies; these sources are discussed in the following sections.

3.2 SURFACE WATER PATHWAY

3.2.1 Hydrologic Setting

Both mine sites are situated along Clear Creek, which flows into Granite Creek approximately 1.1 mi downstream of Bluebird Mine and approximately 1.9 mi downstream of Blackjack Mine. Granite Creek empties into the North Fork John Day River approximately 4.7 mi downstream of this confluence. The town of Granite is on Granite Creek approximately 1 mi upstream of the mouth of Clear Creek.

The Granite Creek watershed encompasses approximately 120-150 square mi (USEPA 1997a), with headwaters originating in the Blue Mountains. There are no stream gaging stations located in the study area (USGS 2003). However, most of the total water yield in the area occurs as snowmelt in May and June, and, except for periodic and localized thunderstorms, rainfall is generally sparse from July to September. Therefore, summer base flows are low relatively compared to the spring snowmelt period. The average annual precipitation ranges from about 10 inches in the lower valleys to 45 inches in the mountains (Brooks, et.al. 1968). In the study area, annual rainfall is roughly 30 inches, about half of which falls as snow (Koch 1959).

The hydrologic functioning of Granite Creek and many of its tributaries has been highly impacted by historical dredge mining. This in turn has significantly altered stream channel morphology and hence floodplain functionality (USDA 2002) . The following observations were made during the SI field investigation regarding the stream flow near the mine sites:

- In 1999, the Forest Service road was moved from the west to the east side of Clear Creek and a major salmon habitat restoration project was conducted in the area of the 2 mines along the creek (Visconty 2003). The new road has essentially separated Clear Creek from the narrow settling pond that collects the drainage from the upper adit at Blackjack Mine (Photo 36). Prior to the construction of the road, the settling pond was located on the same side of the road as Clear Creek (USEPA 1997a).

- Downstream of the narrow settling pond, where Clear Creek turns north, it appears that there is a major inflow of water from Clear Creek into the side channel (and series of ponds), just upstream of sample station BLAC-41. The water flows underneath the road through the dredge tailings that the road was constructed on (Visconty 2003).

- Clear Creek, now located on the west side of the road, is a clearly defined stream. The side channel on the east side of the road is wider and has a much slower flow in comparison to Clear Creek. Previous maps of this area (USEPA 1997a) i ndicated that wetlands, formed in the dredge tailings, used to be present in this area prior to the road construction and restoration of the riparian zone. Dredge tailings are still present above Blackjack Mine, where the restoration area ends.

- Congo Gulch, a small tributary of Clear Creek, drains into the creek just upstream of where the side channel enters the creek. It appears that discharge from the Red Boy Mine also discharges into the creek just upstream of Congo Gulch (Photo 38). At this location, there is a steeper gradient where the side channel joins Clear Creek.

- A large holding pond was constructed on Clear Creek and is located immediately downstream of sample station BLAC-02. This pond was intended as a holding area for the salmon; however, the pond is also used as a public swimming area. Approximately 20 people were observed swimming and recreating at the pond on one occasion just prior to the SI investigation.

3.2.2 Surface Water Targets

A target distance of 15 mi downstream has been identified for the surface water pathway. The surface water drainage route is shown on Plate 2. Potential targets include surface water intakes supplying drinking water, fisheries, sensitive environments (e.g., wetlands), and aquatic species of concern. The 15-mi target distance limit (TDL) for the mines extends along Clear Creek downstream from Bluebird Mine 1.1 mi to its confluence with Granite Creek, along Granite Creek 4.7 mi to its confluence with the North Fork John Day River and another 9.2 mi on the North Fork John Day to the end of the TDL. The last 5.8 mi of the TDL are within the North Fork John Day Wilderness Area, and include reaches of both Granite Creek and the North Fork John Day River.

Because the TDL extends into a Designated Federal Wilderness Area, there appears to be few human targets. The town of Granite is located upstream of the confluence of Clear and Granite Creeks, and obtains its drinking water from an improved spring in the area (USEPA 1997a). There are no designated, developed campsites within the TDL; however, there are numerous dispersed campsites located along open roads outside the Wilderness Area as well as primitive campsites inside the Wilderness Area. A dispersed campsite is one developed by the user, is typically located next to an open road, and often consists of a parking spot and a fire ring. Campers using either type of campsite, along with the occasional miner working a claim, may withdraw drinking water on an individual basis from one of the streams within the TDL.

With the exception of tribal fishing, the TDL does not support commercial fishing activities, and the Oregon Department of Fish and Wildlife (ODFW) has prohibited all recreational fishing in Granite Creek and its tributaries (including Clear Creek) since 1997 in order to protect Chinook salmon (USEPA 1997a).

Sensitive Environments

The sensitive environments present within the 15-mi TDL include:

- North Fork John Day Wilderness Area
- North Fork John Day Wild and Scenic River
- Migratory pathways and spawning areas critical to the maintenance of anadromous fish species
- Habitat potentially used by Federal-designated threatened species.
- Wetlands as defined by 40 CFR 230.3.

Prior to conducting the fieldwork, a list of T&E species and Species of Concern (SOC) potentially occurring in Grant County was generated, obtained from the Oregon Natural Heritage Program (Table 1,

ONHP 2001). In addition, the Oregon Natural Heritage Information Center (ONHIC) was contacted regarding any specific recorded observations of rare or T&E species within a 2 mile radius of the sites (the search range available from the OHNIC (OHNIC 2003).

The aquatic species observed near the Bluebird and Blackjack Mine sites during the SI are included in Table 2. The ONHIC reported the Colu mbia spotted frog (*Rana luteiventris*), a state-sensitive species (undetermined status), as observed within a 2-mile radius of the site (on the Boulder Creek drainage, approximately 1 mile upstream from the town of Granite). On several occasions during the SI, adult spotted frogs were observed at the confluence of Bull Run and Granite Creek near the town of Granite. In addition, one spotted frog was observed in a seine haul on 23 July, along the side channel adjacent to Clear Creek above the Bluebird Mine (near station BLAC-42).

Two Federal-listed threatened species were noted by the ONHIC within a 2-mi radius of the project and may exist in Clear Creek, including bull trout (*Salvelinus confluents*) and steelhead (*Oncorhynchus mykiss*). These species are designated by the State of Oregon as sensitive-critical (bulltrout) and sensitive-vulnerable (steelhead). The westslope cutthroat trout (*Oncorhynchus clarki lewisi),* designated as a federal-SOC and state -vulnerable species, was also reported as observed within 2 miles of the sites by the ONHIC.

ODFW has reported the presence of both westslope cutthroat trout and inland/interior redband trout (*Oncorhynchus mykiss gairdneri*), a federal-SOC and state-sensitive species, in the Clear Creek drainage (Unterwegner 2003). Small juvenile salmonids identified as either i nland/interior redband trout or westslope cutthroat trout, were observed in the seine hauls in Clear Creek during the SI (discussed further in Section 3.2.4). In addition, ODFW has reported the pr esence of bull trout in the first 2 mi of the upper headwaters of Clear Creek (USDA 2002). Bull trout were not encountered in the seine hauls in Clear Creek during the SI. Bull trout were found in the upper portions of Granite Creek during the SI field investigation conducted in that area prior to the Bluebird/Blackjack field investigation (EA 2003d). The elevation at which the bull trout were observed along Granite Creek ranged from 5,200 to 5,800 ft ASL, at least 500 ft higher than the Clear Creek sites.

Birds and Waterfowl

Species of birds that are associated with the streams and ponds are of concern due to their potential exposure to contaminants released from the mines. The birds and waterfowl observed during the SI are listed on Table 2. Notable species observed in the vicinity of the sites include:

- Spotted sandpiper (*Actitus macularia*)
- Dipper (*Cinclus mexicanus*)
- Great blue heron (*Ardea herodias*)
- Belted kingfisher (*Ceryle halcyon*).

These birds forage on stream invertebrates and fish and therefore are of particular concern. There was evidence of nesting kingfishers (Photo 53). In addition, there was adequate habitat for the sandpipers and dippers to nest; however, because it was past the nesting season at the time of the survey, no nesting activity was observed. Young mallards (*Anas platyrhynchos*) and Canada geese (*Branta canadensis*) were observed using the ponds across from the Bluebird Mine (on the east side of Clear Creek). All of these species could have exposure to contamination from the mines from a variety of sources, through dermal contact in pond water and sediment, as well as ingestion of water, sediment, and prey.

Despite the paucity of vegetation in the riparian area, there were species of birds typically associated with the riparian zone, such as Lincoln's (*Melospiza lincolnii*) and song sparrow (*Melospiza melodia*), American robin (*Turdus migratorius*), and MacGillivray's warbler (*Oporornis tolmiei*). These species would be expected to have different exposures, with less exposure to stream associated organisms, but potentially some dermal and water exposures. The SOC observed in the area of the mine sites included the olive-sided flycatcher (*Contopus cooperi*), heard calling on one occasion on the hillside. The flycatchers are associated with the tops of large snags, abundant on the hillsides in the vicinity of the sites, from which they flycatch insects and build their nests. Exposure in these birds would be restricted to ingestion of flying insects.

Wetlands Assessment

The National Wetlands Inventory (NWI) Database 7.5 minute topographic map for the Granite quadrangle (NWI 1994) was examined and compared to wetlands observed in the project area. Several of the wetland ponds in the vicinity of the Bluebird and Blackjack Mine sites were excavated out of the dredge tailings during the stream restoration project and road construction in 1999. Since these ponds were constructed after the completion of the 1994 NWI map, the wetlands could not be compared to the classification on the map. For a detailed description of the wetlands, refer to Appendix E.

Clear Creek in the vicinity of the Bluebird and Blackjack Mines was characterized on the NWI map as *Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded*(R3UBH) with a section between the mines as *Riverine, Intermittent, Streambed, Semi-permanently Flooded*(R4SBF). The stream is now perennially-flowing in this area (R3UBH), presumably a result of the stream restoration project and the road construction.

There are a large number of palustrine wetland ponds across from the Bluebird Mine, on the west side of the road and Clear Creek. AMD from the Bluebird Mine drains into the uppermost pond via a discharge pipe that runs underneath the creek and road. Classification of these ponds was difficult because they are located on private property. These ponds appear to be recently excavated and they lack any scrub-shrub development. Considering they contained water during the driest portion of the year, they can be considered permanently flooded and likely classified *as Palustrine Unconsolidated Bottom, Permanently Flooded, Excavated (PUBHx).* These ponds are identified as wetlands on the NWI map as follows:

PABHx - *Palustrine Aquatic Bed Permanent Flooded, Excavated*
PSSCx - *Palustrine Scrub Shrub Seasonally Flooded, Excavated*
PUBHx - *Palustrine Unconsolidated Bottom, Permanent Flooded, Excavated*
PEMCx – *Palustrine Emergent Vegetation, Seasonally Flooded, Excavated*
PEMF – *Palustrine Emergent Vegetation, Semi-Permanently Flooded*
PSSA – *Palustrine Scrub-Shrub Temporarily Flooded*

The flow from the upper adit at the Blackjack Mine discharges through a pipeline into a narrow excavated pond (not on the NWI map). This pond (or ditch) flows into a larger side channel located on the east side of Clear Creek. The channel is also supplemented by flow from the creek, which filters through the dredge tailings under the road. This channel, also not on the NWI map, is *a Riverine Upper Perennial, Unconsolidated Bottom Permanently Flooded* (R3UBH) wetland. The status of this wetland may change as the flow coming from Clear Creek varies over time (see Appendix E). The flow from the lower adit at Blackjack discharges to a small scrub-shrub wetland. The origin of this wetland is unclear, but it was likely excavated.

3.2.3 Stream Sampling Locations

Locations of stream samples at the Bluebird and Blackjack Mines collected during the SI are indicated on Figures 1 and 2, respectively. A number of modifications to the sampling locations and techniques were made in the field, based on site observations and field conditions, and with concurrence of the Forest Service On-Scene Coordinator (OSC). These modifications are documented in Appendix A.

Blackjack Mine

One reference stream location and 3 locations along Clear Creek downstream of Blackjack Mine were sampled for the SI. In addition, samples were collected from the adit discharge and several samples were collected in the settling pond and side channel on the east side of the creek. The following stations were sampled:

Station ID	Location	Matrices Collected
BLAC-01	On Clear Creek approximately 300 ft upstream of the Blackjack Mine upper adit and area of iron staining along the left descending stream bank.	One surface water sample, 1 sediment sample (pool habitat), and 1 pore water sample (pool habitat).
BLAC-02	On Clear Creek, approximately 150 ft downstream of the Blackjack Mine lower adit and approximately 100 ft upstream of a large constructed holding pond/swimming hole.	One surface water sample, 2 pore water samples (riffle and pool), and 2 sediment samples (riffle and pool).
BLAC-02A	Sample station BLAC-02 was re-sampled after the spill from the upper adit at Blackjack.	One surface water sample, 1 pore water sample (pool), and 1 sediment sample (pool habitat).
BLAC-03	Downstream of Station BLAC-02, and immediately downstream of where some flow from the creek infiltrates under the road into the side channel on the east side of the road.	One surface water sample, 2 pore water samples (riffle and pool), and 1 sediment sample (pool habitat).
BLAC-03A	Sample station BLAC-03 was re-sampled after the spill from the upper adit at Blackjack.	One surface water sample, 1 pore water sample (pool), and 1 sediment sample (pool habitat).
BLAC-04	Downstream of Station BLAC-03, just upstream of where Congo Gulch (a small tributary) enters Clear Creek. This location was just upstream of Red Boy Mine, however, some red staining was observed on the shoreline just slightly upstream of the sample location, indicating some influence from Red Boy Mine may be present in this location.	One surface water sample, 1 pore water sample (pool habitat), and 2 sediment samples (riffle and pool).
BLAC-43	In the marshy area (where the lower adit discharges).	One surface water and 1 sediment sample.
BLAC-10 & BLAC-15	In the settling pond on the east side of Clear Creek. BLAC-15 was located near the discharge pipe from the upper adit and BLAC-10 was located at the downstream end of the pond.	One surface water sample each and 1 sediment sample at BLAC-10.
BLAC-41 & BLAC-42	In the side channel and series of ponds on the east side of the creek. Station BLAC-41 was located just downstream of where the creek water flows from under the road into the uppermost pond (in the series). Station BLAC-42 was located in the flowing portion of the side channel just upstream of where the side channel discharges into Clear Creek.	Samples collected at station BLAC-41 included: 1 surface water sample and 1 sediment sample. Samples collected at station BLAC-42 included: 1 surface water sample, 1 pore water sample (riffle habitat), and 2 sediment samples (riffle and pool).

Bluebird Mine

One reference location and 3 locations along Clear Creek downstream of the Bluebird Mine site were sampled for the SI. In addition, sample stations were also located at the adit and in the ponds on the west side of Clear Creek to document potential impacts and migration of contaminants coming from the adit discharge pipe. The following stations were sampled:

Station ID	Location	Matrices Sampled
BLUE-05	On Clear Creek, upstream of Bluebird mining activities and approximately 400 ft downstream of the mouth of Congo Gulch. This station was located just downstream of potential influences from Red Boy Mine.	One surface water sample, 2 pore water samples (riffle and pool), and one sediment sample (pool habitat).
BLUE-05A	Sample station BLUE-05 was re-sampled after the spill from the upper adit at Blackjack. The samples were identified with an "A" at the end of the location number (i.e. BLUE-05A).	One surface water sample, one pore water sample (pool), and one sediment sample (pool habitat).
BLUE-06	On Clear Creek, approximately 225 ft downstream of the red-stained channel coming from the adit at Bluebird Mine.	One surface water sample, 2 pore water samples (riffle and pool), and one sediment sample (pool habitat).
BLUE-07	On Clear Creek, approximately 225 ft downstream from the BLUE-06 sampling location to document downstream migration potential.	One surface water sample, 2 pore water samples (riffle and pool), and one sediment sample (pool habitat).
BLUE-08	On Clear Creek, approximately 300 ft downstream of BLUE-07, but upstream of the Mineral Wonder Mine, also to document migration of potential contaminants.	One surface water sample, 2 pore water samples (riffle and pool), and 2 sediment samples (riffle and pool).
BLUE-19	At the adit portal.	One surface water sample was collected from the discharge pipe cleanout adjacent to the mouth of the adit.
BLUE-18	In the pond, located on the west side of Clear Creek. The pond was sampled near the outlet of the discharge pipe which carries flow from the adit at Bluebird Mine. The outlet of the pipe is located below the surface of the pond and the pipe itself was not visible. The location was determined by the flow of water coming into the pond.	One surface water sample and one sediment sample.
BLUE-17	Reference station that was located upstream of the outlet pipe in the pond (Station 18) and below the probable point of entry of contaminants from Red Boy Mine.	Because the pond is located on private property, only a surface water sample was collected at this location.
BLUE-16	Located downstream of BLUE-18 in ponds on the west side of Clear Creek.	One surface water sample and one sediment sample.

3.2.4 Aquatic Survey Results

Aquatic surveys were conducted to assess the impact, if any, of the Ajax or Magnolia mine sites on the benthic macroinvertebrate community, presence of fish species, and habitat quality. Survey results are presented in Appendix F (Tables F-1 through F-5). Field collection efforts were conducted according to the methods stated in the project plans (EA 2003a, 2003c).

Sampling of benthic macroinvertebrates was conducted in pool and riffle habitat at a total of 9 stream stations associated with the Blackjack and Bluebird Mine sites. Stations included BLAC-01 (the upstream reference site for Blackjack Mine site), BLAC-02, BLAC-03, BLAC-04, BLAC-42, BLUE-05 (the upstream reference site for Bluebird Mine site), BLUE-06, BLUE-07, and BLUE-08. Stream characteristics for each sample station are presented in the following table:

Stream Station Characteristics

Station	Habitat (%)			Dominant Substrate	Water Depth (in.)		Current Velocity (ft/sec)	
	Riffle	Pool	Run		Riffle	Pool	Riffle	Pool
Blackjack Mine								
BLAC-01	60	30	10	Cobble/boulder	4-7	12-30	2.5	0.1
BLAC-02	50	40	10	Cobble/boulder	0.5-3.5	3-7	1.4	0.48
BLAC-03/04	60	40	10	Cobble/boulder	0.25-8	3-18	1.3/ 1.5	0.0/0.03
BLAC-42	20	50	30	Pool - fine silt Riffle - gravel	3-12	3-21	1.9	0.02
Bluebird Mine								
BLUE-05	50	25	25	Riffle – cobble, gravel, and boulder Pool – the above with silt	3-9	12-30	2.3	0.2
BLUE-06	40	40	20	Boulder, cobble, and gravel	2-6	24-48	2.1	0.03
BLUE-07	50	30	20	Cobble/boulder	1-10	9-55	1.3	0.2
BLUE-08	50	25	25	Cobble/boulder	1-10	9-55	2.6	0.5

Benthic Macroinvertebrate Survey Results

Benthic macroinvertebrate data from pool and riffle habitats were evaluated to determine possible effects from the 2 mines on the benthic macroinvertebrate community. Laboratory sorting of benthic macroinvertebrate samples was conducted in accordance with the Oregon Department of Environmental Quality (ODEQ) methods and evaluated using a multi-metric analysis. The findings of the benthic macroinvertebrate sampling are as follows.

- Riffle index scores remained consistent throughout the stations when compared to the upstream references.
- Pool index scores, while lower than riffle scores, were consistent among the stations.
- The index scores indicate that neither of the mine sites has a significant adverse effect on Clear Creek.

Four pool and 4 riffle stations were sampled for benthic macroinvertebrates after the spill of AMD from the upper adit at Blackjack Mine into Clear Creek. The Blackjack reference station (BLAC-01) was again sampled to provide data from an upstream reference site. Station BLAC-02, directly downstream from the mine site and the release area was sampled to provide data on the effects of the spill directly downstream. Stations BLAC-03 and BLUE-05 were sampled to measure any effect of the spill at stations farther downstream from the spill site.

Macroinvertebrate data collected after the spill were compared to evaluate potential impacts of the spill on the benthic macroinvertebrate community of Clear Creek (Tables F-1A, F-2A and F-3A). First, the downstream stations were compared to the upstream reference site for the data collected after the spill. Second, the data collected at the 4 stations after the spill were compared to the data collected at those sites during the SI. Findings are as follows:

- Index score for both the riffle and pool habitats at the Blackjack reference station were lower after the spill than the pre-spill period.

- The decrease in scores at the reference station (as well as the downstream stations) after the spill could be attributed to sample variability, insect emergence since the July sampling effort, or other factors not associated with the spill.

During the initial site assessment, small isolated areas of flocculent iron precipitate were observed along the banks at station BLAC-03. The aerial extent of the iron floc was substantially greater after the Blackjack Mine spill with approximately 75 percent of the pool substrate and 30 percent of the riffle substrate being covered at Station 03.

Visual observation of this station immediately downstream from the mine site subsequent to the spill event documented physical effects from the spill. Flocculent iron precipitate was evident in the pool habitat, where it had apparently settled after the release of the mine water into Clear Creek. Nearly 100 percent of the pool substrate and 50 percent of the riffle substrate was coated with flocculent at BLAC-02.

- Total score for the riffle habitat at BLAC-02 was higher than at the reference station and similar to the score in July, prior to the spill.
- Total score in the pool habitat at BLAC-02 was slightly lower than at the reference station in the August sample, but considerably lower than the sample collected in July.
- Although all the stations sampled after the spill exhibited a decrease in index scores, the magnitude of the decrease in score in the pool habitat at Station 02 suggests that the spill had some effect on the benthic macroinvertebrate community at this station. On the other hand, the decrease in numerical abundance at this station between July and August was less than at any other station, so it is not clear that there were impacts at this station.
- Assuming that the spill did affect BLAC-02 (as well as other downstream stations) that impact could be attributed to either physical or chemical effects. However, it is probable that the accumulation of flocculent precipitate, in part, contributed to the adverse effects on the pool benthic community at the station directly downstream from the spill.
- The magnitude of the post-spill reduction in the pool habitat index score at Station BLAC-02 compared to the reduction in pool scores at the other locations supports the conclusion that the spill had an adverse effect on the pool community at this station. However, the lack of change in riffle scores between the pre- and post-spill periods indicates that the riffle community at BLAC-02 was not affected.
- The extent of the flocculent precipitate in the pool habitat at Station 02 suggests that the effect of the spill on the benthic macroinvertebrate community can, at least in part, be attributed to a physical effect.
- No effects of the spill were evident in the benthic macroinvertebrate communities at downstream Stations 03 and 05.
- In summary, the effects of the mine spill on benthic macroinvertebrate communities downstream from the spill were localized and habitat specific, being apparent at downstream pool Station 02 only.

Fish Presence or Absence

Seining and fish observations were conducted as part of this SI. Activities were conducted in likely habitat at 10 stream stations associated with the Blackjack and Bluebird Mine sites. In general, fish collection efforts coincided with benthic macroinvertebrate and water sampling stations. Additional observations of fish in the area are also included in support of the seining efforts to better characterize the extent of utilization of this portion of Clear Creek by fish communities. Because Clear Creek is a relatively swift stream with moderate depths, seining efforts were limited to those areas where the biologist could successfully deploy the seine. The seining effort was by no means exhaustive, so it is likely other species may be present and that the species collected are considerably more abundant than the data suggests.

No ecologically significant fish barriers were observed within the study area, which was supported by the collection of young-of-year (YOY) and juvenile migratory salmonids at the farthest upstream station within the study area. Collection of these YOY fish at the upstream reference site indicate that spawning is conducted within and upstream from the study area. Upstream migration and navigation of Clear Creek by adult fishes, at least during the spawning season is successful. A total of 4 species of fishes were captured and/or observed at the 10 stations near the 2 mine sites during the July sampling. Results of fish collection efforts were as follows.

Blackjack Mine Site

Species	Station					
	01 (ref.)	**02**	**03**	**04**	**41**	**42**
Oncorhynchus tshawytscha	~100	10	75	60	0	0
Oncorhynchus mykiss	2	0	0	1	4	0
Cottus rhotheus	3	0	3	2	3	3
Rhinichthys osculus	2	0	1	20	0	51

The chinook salmon (*Oncorhynchus tshawytscha*), observed near the Blackjack Mine site, is a migratory species; therefore, it is difficult to assess any impact resulting in their presence or absence from any particular station related to the mine. Adult salmon move freely within Clear Creek. A nother salmonid species, either inland/interior redband trout (*Oncorhynchus mykiss gairdneri*) or westslope cutthroat trout, (*Oncorhynchus clarki lewisi)* was also observed. Both of these species are considered Federal-listed SOC and State Vulnerable. The specimens observed in the seine hauls were juveniles. At this stage of development, the two species look nearly identical and are very difficult, if not impossible, to separate them in the field. An accurate identification would require laboratory examination, which was not allowed under the collection permit. The state indicated that both species might be present in Clear Creek. The other 2 species of fish collected in the seine hauls at the Blackjack Mine site were torrent sculpin (*Cottus rhotheus*) and speckled dace (*Rhinichthys osculus).* These species, as well as the trout, are more localized in their movement within the system, with the two former species being more associated with the benthic (bottom) habitat within the stream.

Bluebird Mine Site

Species	Station			
	05	**06**	**07**	**08**
Oncorhynchus tshawytscha	60	0	10	20
Oncorhynchus mykiss	0	1	0	0
Cottus rhotheus	1	1	3	2
Rhinichthys osculus	30	10	50	75

The same 4 species of fishes were collected or observed at the Bluebird Mine site as were collected or observed at the Blackjack Mine site. Again, the data shows that these species occur throughout the study area, and no real impact from the mine site is evident.

Fish collection efforts were conducted after the spill in the same manner in which they were conducted prior to the spill. Fish collections and observations were only conducted at the 4 stations coinciding with the benthic macroinvertebrate stations sampled after the spill: Stations BLAC-01, 02, and 03 and BLUE-05. Data show that fish were common and widely distributed throughout the study area both before and after the spill, suggesting that the impact was minimal.

Blackjack/Bluebird Post-Spill

Species	Station			
	01A (ref.)	**02A**	**03A**	**BLUE-05A**
Oncorhynchus tshawytscha	3	100	0	5
Oncorhynchus mykiss	5	10	5	10
Cottus rhotheus	0	2	2	6
Rhinichthys osculus	0	0	0	2
Cottus beldingi	0	0	1	0

One additional species, paiute sculpin (*Cottus beldingi*), was captured at the Blackjack Mine site. It is likely that this species was not observed in the pre-spill collections because of the low level of effort expended during the pre-spill period.

Bluebird Mine site 05 produced three species before the spill and four species after it. The limited fish data do not indicate any ecologically significant effects from the spill.

Habitat Composition

Habitat was evaluated at each of the 4 stream stations to support and compare with benthic macroinvertebrate data and fish presence or absence data. Habitat was evaluated in accordance with those methods stated in the WP/SAP (EA 2003a). Habitat scores for Clear Creek are presented in Appendix F, Table F-5. Evaluation of aquatic habitat in Clear Creek, within the project area, and it is the ability to support healthy macroinvertebrate and fish communities indicate that Clear Creek is conducive to both among all stations where biological collections were conducted.

- Noticeably more silt was observed in the pool at Station 05 than at any other Clear Creek station. The dirt road and bridge crossing, immediately upstream of the station, may be the source for a majority of the instream silt observed at this station.

- Habitat scores at Blackjack Mine site ranged from a low score of 147 (out of a maximum of 200) at Station 42 (the added station in the side channel of Clear Creek), to 183 at Station 04.
- Habitat scores at Bluebird Mine site ranged from a low score of 151 at Station 05 (the reference station for Bluebird), to 182 at Station 08.
- Habitat scores at the stations located within the study area indicate that physical habitat conditions are not a limiting factor to support healthy macroinvertebrate and fish communities.
- Impact from the mine site had minimal influence, if any, on the habitat scores for stations on Clear Creek.

3.2.5 Analytical Results

Analytical water quality results for surface water, pore water, and sediment samples are presented in Appendix G (Tables G-1, G-2, and G-3, respectively). Only those constituents detected in one or more samples are included in the summary tables. Dissolved metals concentrations were used for comparison with surface water screening criteria. Photographs of selected sample locations are provided in Appendix B. Copies of the laboratory reports are included in Appendix J, and a quality assurance/quality control summary is provided in Appendix K.

In situ water quality parameters were measured in conjunction with sampling efforts. Surface water quality parameters were measured in riffle and pool habitat at each station. Pore water quality parameters were measured in water samples extracted from pool habitat (Appendix G, Table G-2). *In situ* water quality measurements for the surface water and pore water are reported in Appendix G (Tables G-1 and G-2, respectively).

- *In situ* water quality parameters consisted of: hexavalent chromium, temperature (°C), dissolved oxygen (mg/l), specific conductance (mS/cm ^{3}), pH (standard units), turbidity (NTU), redox potential (ORP) and current velocity (ft/s).
- The pH values at the adits of both Blackjack and Bluebird Mine sites were low (5.5-6.2); however, these values do not extend to the stations immediately downstream from the mines on Clear Creek.
- Mitigation at the site (settling ponds and redirection of flow from the mine adits) appear to be sufficiently buffering *in situ* water quality deficiencies and consequently not effecting Clear Creek.
- *In situ* water quality measurements did not indicate that these parameters were a limiting factor which would preclude sustainable benthic macroinvertebrate and fish communities at any of the stream stations sampled.

Laboratory analyses performed include the following:

- Surface water – pH, Target Analyte List (TAL) metals (total and dissolved), arsenic III and V (total metals only), cyanide, TDS, total suspended solids (TSS) (TSS, organic, and inorganic), hardness, alkalinity, specific conductance, oxidation/reduction potential (Eh), and sulfate.

- Pore water –dissolved TAL metals, arsenic III and V (total metals only), and cyanide.

- Sediment – TAL metals, cyanide, Total Organic Carbon (TOC), grain size, and clay mineralogy (for samples collected in pools only).

In addition, for the pore water and sediment samples collected during the Blackjack Spill Response sampling event, the following parameters were added to the above analytical suite at the request of the OSC:

- Pore water –TDS
- Sediment – Synthetic Precipitation Leaching Procedure (SPLP).

Criteria for comparing measured concentrations of metals in surface water and pore water consist of the following human health and ecological screening values:

- ODEQ (2003) Water Quality Criteria, Protection of Aquatic Life, Fresh Chronic Criteria; hardness-dependent values (cadmium, chromium III, copper, lead, nickel, silver, zinc) are based on mean hardness (128 mg/L) from the surface water samples collected on Clear Creek.

- ODEQ (2003) Water Quality Criteria, Protection of Human Health, Water, and Fish Ingestion.

- ODEQ (1998) Guidance for Ecological Risk Assessment, Level II Screening Values for surface water; these values are based on previous USEPA water quality criteria that have been superseded by the USEPA (2002) recommendations for ambient water quality criteria for freshwater organisms.

- USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, chronic; hardness-dependent values are normalized to 128 mg/L (mean stream hardness).

- USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, Tier II secondary chronic values calculated by Oak Ridge National Laboratory (Suter and Tsao 1996).

- USEPA (2002) recommended ambient water quality criteria for protection of human consumption of fish; hardness-dependent values are normalized to 128 mg/L (mean stream hardness).

- Oak Ridge National Laboratory, U.S. Department of Energy (Efromyson, et. al. 1997), Preliminary Remediation Goals.

The results are summarized in the following table (elevated concentrations refers to concentrations detected above at least one of the comparison criteria values).

Summary of Surface Water and Pore Water Metals Data

Sample Type	Data Table	Dissolved Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Stream Surface Water	Table G-1		
Bluebird Mine		Barium	Barium was detected above the comparison criteria in all of the surface water samples, at comparable concentrations to the level detected in the reference sample (BLUE-05).
Blackjack Mine		Arsenic, barium, and lead.	All 3 metals were detected above the comparison criteria in the reference sample collected upstream of Blackjack Mine (BLAC-01). The only metals elevated in the downstream samples were barium and lead, at comparable concentrations to the reference sample concentrations.
Adit Discharge	Table G-1		
Bluebird Mine Adit		Barium, cobalt, iron, manganese, mercury, nickel, and zinc.	Of the metals detected in the adit sample, cobalt, iron, manganese, mercury, nickel, and zinc were detected at concentrations above the comparison criteria in the pond samples downstream of the pipe discharge outlet. Barium was detected above the comparison criteria in all samples in the ponds, as well as the pond reference sample, BLUE-17 (at a higher concentration).
Blackjack Mine Lower Adit		Barium, iron, lead, manganese, mercury, and nickel.	Of the metals detected in the lower adit sample, only lead was detected above the comparison criteria in the downstream Clear Creek samples; however, the level was the same as the reference concentration. Lead was not detected in the sample collected in the marshy area just downgradient of the lower adit discharge point (BLAC-43). Manganese and mercury were elevated in the sample collected at BLAC-43. Manganese was not elevated above the comparison criteria and mercury was not detected in the sample collected at station BLAC-02, downstream of where the marshy area drains into the creek.

Sample Type	Data Table	Dissolved Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Pond Surface Water	Table G-1		
Bluebird Mine		Aluminum, barium, cobalt, iron, lead, manganese, mercury, nickel, selenium, and zinc.	All of the metals detected above the comparison criteria in the pond surface water samples were also detected at elevated concentrations in the sample collected from the adit (except aluminum). Cobalt (low), iron, manganese, mercury, nickel, and zinc were all detected above the comparison criteria in the adit, as well as the pond samples downstream of the pipe outlet in the pond (BLUE-16 and 18). In general, the concentrations of dissolved metals did not vary significantly between the 2 samples (with the exception of iron, which was notably higher in BLUE-18). Of the metals detected at elevated concentrations in the 2 downstream samples, barium, manganese, and nickel were also elevated in the reference sample. With the exception of barium, the reference sample showed lower concentrations of dissolved metals in comparison to the 2 samples collected downstream of the pipe outlet. It should also be noted that the pH levels measured in the settling pond were below the ecological recommended level of 6.5 pH units.
Blackjack Mine		Aluminum, barium, cadmium, cobalt, copper, iron, manganese, mercury, nickel, selenium, and zinc.	A sample of the water flowing from the upper adit could not be collected, however, 2 samples were collected in the settling pond (BLAC-15 and 10). With the exception of iron, in general, the dissolved metals concentrations did not vary significantly between the 2 pond samples collected in the settling pond. Iron was higher in the upstream sample (BLAC-15), closer to the pipe outlet. The surface water sample collected at the lower pond (BLAC-41) did not contain any detections of dissolved metals, with the exception of barium, which was close to the concentration detected in the reference sample. The surface water sample collected from the marshy area downgradient of the lower adit (BLAC-43) contained manganese and mercury above the comparison criteria. This sample station appears to be impacted by the AMD flowing from the adit. It should also be noted that the pH levels measured in the settling pond, as well as the marshy area, were below the ecological recommended level of 6.5 pH units.
Pore Water	Table G-2		
Bluebird Mine		Barium, and mercury.	Barium was within the range of the reference samples. Mercury was detected just above the method detection limit in 3 of the most downstream samples.
Blackjack Mine		Aluminum, barium and mercury.	Aluminum was detected above the comparison criteria in the sample collected at BLAC-42. However, it should be noted that aluminum cannot be attributed to onsite sources based on the analytical results (see surface water and soil/waste sample results). Barium was detected above the criteria within the range of the reference samples. Mercury was elevated at BLAC-02 at a concentration just above the method detection limit but below the method reporting limit.

Criteria for comparing measured concentrations of metals in sediments were based on the following:

- Threshold Effects Level (TEL) and Probable Effects Level (PEL) from USEPA National Sediment Quality Survey, Screening Values for Chemicals Evaluated http://www.epa.gov/waterscience/cs/vol1/appdx_d.pdf).

- Effects Range-Low (ER-L) and Effects Range-Medium (ER-M), National Oceanic and Atmospheric Administration (NOAA), from USEPA (1997b) National Sediment Quality Survey, Screening Values for Chemicals Evaluated.

- ODEQ (1998) Guidance for Ecological Risk Assessment, Level II Screening Values for freshwater sediment.

The analytical results for the sediment samples are provided in Table G-3. It should be noted that the pond and adit sediment samples for both sites contained the highest percentages of silt and clay in comparison to the other samples. The results are summarized in the following table.

Sample Type	Data Table	Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Stream Sediment	Table G-3		
Bluebird Mine		Arsenic, total chromium, copper, mercury, and nickel.	All of the dissolved metals detected above the comparison criteria in the samples downstream of Bluebird Mine were also elevated in the reference sample. The concentrations for arsenic, total chromium, copper, and nickel were slightly higher in the samples collected at BLUE-05 after the Blackjack spill.
Blackjack Mine		Arsenic, total chromium, copper, manganese, nickel, and silver.	BLAC-42 was collected in the side channel, and therefore is discussed with the pond samples below. None of the metals detected above the comparison criteria in the stream sediment samples were notably above the concentrations detected in the reference sample. Overall, the higher concentrations were detected in the sample collected at BLAC-02, just downstream of the lower adit discharge point. With the exception of 1 sample, the concentrations of arsenic, total chromium, copper and nickel were slightly lower in the samples collected after the Blackjack spill.
Pond Sediment	Table G-3		
Bluebird Mine		Antimony, arsenic, cadmium, copper, manganese, nickel, and zinc.	Due to private property, sediment was only collected from the downstream station BLUE-16, located on Forest Service property. Concentrations of arsenic, manganese, nickel, and zinc were notably above the comparison criteria in this sample. The high percent of fines measured in this sample should also be noted. Antimony, cadmium and copper were also notably above the comparison criteria, although no reference sample could be collected for comparison purposes.

Sample Type	Data Table	Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Blackjack Mine		Antimony, arsenic, cadmium, total chromium, copper, manganese, mercury, nickel, silver, and zinc.	In general, the highest concentrations were detected in the sample collected from station BLAC-41, the most upstream pond in the side channel where Clear Creek flows under the road (through the dredge tailings). This is likely due to the higher silt/clay content in this sample compared to the stream sediment samples. Almost all of the metals detected above the comparison criteria in the upstream sample were also detected in the downstream sample (BLAC-42), but at lower concentrations. Chromium and mercury were elevated in the downstream sample at higher concentrations than the upstream sample. Antimony and silver were elevated in the downstream sample, however, these were not in the upstream sample. Arsenic, copper, and mercury were detected above the comparison criteria at the downstream end of the settling pond (a sediment sample was not collected at the upstream end of the settling pond, at station BLAC-15, because no sediment was present).

3.2.6 Surface Water Pathway Summary

Observations of the biological and analytical results follows:

Blackjack Mine

- There does not appear to be a significant release of metals to surface water in Clear Creek from the adits or waste piles at the Blackjack Mine site when compared to the reference sample results. The metals that occurred above the comparison criteria, including barium and lead, are similar to the concentrations detected in the surface water reference samples (Table G-1).

- There is evidence of an ongoing release of metals from the adits to the surface water in the settling pond downstream of the site and the marshy area along the drainage route from the lower adit. These metals included aluminum, barium, cadmium, cobalt, copper, iron, manganese, nickel, selenium and zinc. Two metals were detected above the comparison criteria in the marshy area downgradient of the lower adit, including manganese and mercury.

- Barium and mercury were detected above the comparison criteria in the pore water samples collected at the downstream locations , however, they were not notably above the reference sample concentrations (Table G-2).

- A number of metals, including arsenic, total chromium, copper, and nickel were detected at concentrations exceeding the comparison criteria in the sediment samples collected from Clear Creek, however, none of the concentrations were notably above the reference sample concentrations (Table G-3).

- The sediment in the ponds downstream of the site appears to be impacted by contamination potentially migrating from the site. A number of metals, including antimony, arsenic, cadmium, total chromium, copper, manganese, mercury, nickel, silver, and zinc were detected at concentrations exceeding the comparison criteria values.

- Observed impacts on Clear Creek near the Blackjack Mine site included visible iron precipitate coatings on stream substrate downstream of the Blackjack Mine to sampling station BLAC-02. The *in situ* water quality measurements indicate some water quality degradation in the lower adit sample, but it does not appear that Clear Creek is being impacted (Table G-1). The pool habitat score was lower at station BLAC-02, the station located just downstream of the site, compared to the reference station, although it is not conclusive that this is due to impacts from the site. Overall, there does not appear to be significant benthic habitat impairment or decreased benthic macroinvertebrate diversity and numbers along Clear Creek downstream from the site. In July, taxa richness at station BLAC-02 was as high or higher than at the reference station BLAC-01. During the post-spill sampling in August, taxa richness was lower in the pool habitat at BLAC-02, however, the metric score remained unchanged (with a score of 3 at both BLAC-01 and BLAC-02).

- The aquatic survey scores indicates that there may be some adverse influence from the Blackjack Mine downstream to station BLAC-02, as indicated by a lower taxa richness score and flocculent iron precipitate present on the shoreline and substrate. These adverse conditions appear to be limited to station BLAC-02.

- The metals concentrations in the surface water, pore water and sediment samples collected after the Blackjack spill were not significantly higher, and in some cases were lower, than the concentrations in the samples collected in July. The aquatic survey results suggest that Clear Creek was not significantly impacted by the spill. The data indicates that if there was an effect on the benthic community, it was limited to the pool habitat at station BLAC-02. However, the impact at this station is not statistically significant considering the score at BLAC-02 was only 4 points lower than at the reference station. It should be noted, however, that the samples were collected 10 days after the spill occurred, and some short-term impacts may have taken place during that time.

Bluebird Mine

- There does not appear to be a release of metals to surface water in Clear Creek from the adit or waste piles at the Bluebird Mine site when compared to the reference sample results (Table G-1). The only dissolved metal detected above the comparison criteria was barium and the concentrations detected in the surface water downstream of the reference sample were either similar to or below the concentration detected in the reference sample. It should be noted that the TDS result in the reference sample was much higher than the downstream sample results.

- There is evidence of an ongoing release of metals from the adit to the surface water in the ponds downstream of the pipe discharge outlet. Dissolved metals detected above the comparison criteria in both the adit water sample and the settling pond at the Bluebird site were aluminum, cobalt, iron, manganese, mercury, nickel, and zinc.

- Mercury was detected above the comparison criteria and the reference sample concentrations in pore water samples collected in Clear Creek (Table G-2). The increases in the concentrations were not statistically significant; therefore, it cannot be concluded that these increases are due to impacts from the site.

- Nickel and copper were detected in downstream sediment samples collected in Clear Creek at concentrations exceeding the comparison criteria. However, the concentrations were not notably above the reference sample concentrations (Table G-3).

- The sediment collected from BLUE-16, the most downstream pond location, appears to be impacted by antimony, arsenic, cadmium, copper, manganese, nickel, and zinc, all detected above the comparison criteria. Several of these metals were significantly above the comparison criteria values, including arsenic, manganese, nickel, and zinc.

- The AMD from the adit discharges through a PVC pipe to the settling pond. Occasionally, water backs up in the pipe and overflows directly into the creek. The field parameters indicate some water quality degradation in the adit sample at the mine, but the water quality in Clear Creek appears unaffected (Tables G-1 and G-2).

- There does not appear to be significant benthic habitat impairment or decreased benthic macroinvertebrate diversity and numbers along Clear Creek downstream from the site.

- Habitat conditions were generally good at the Bluebird Mine stations sampled along Clear Creek. However, at Station BLUE-06 (the nearest downstream station to the Bluebird Mine), the index score suggests some level of impairment in the pool habitat when compared to the reference station.

- According to the biological and analytical results, the habitat and water quality conditions at Station BLUE-05 do not appear to have been adversely affected by the Blackjack spill. The sediment sample concentrations were slightly higher in the sample collected after the spill, but not statistically significant.

3.3 SOIL EXPOSURE PATHWAY

3.3.1 Targets

There are no onsite workers and no people who live onsite or within 200 ft of areas of suspected contamination related to the site. The closest regularly occupied building appears to be located at the Red Boy Mine, approximately 0.25 mi from the Bluebird Mine and 0.75 mi from the Blackjack Mine (aerial distances). The town of Granite is located approximately 2.75 mi from the Bluebird Mine and 3.2 mi from the Blackjack Mine (aerial distance). It is reported that approximately 24 people live in the town of Granite (USCB 2002). Furthermore, it is estimated that there are approximately 50 permanent residents located within a 4-mi radius of the mine sites (Plate 1).

The site is open to public access and no warning signs were observed onsite. Land uses within a 4 mile radius of the sites include recreation (hiking, fishing, swimming, camping, all-terrain-vehicle use, etc.), mining on nearby claims, and limited timber harvesting. People were observed swimming and recreating in and around the swimming hole downstream of Blackjack Mine during the SI investigation.

Soil exposure targets also include sensitive environments located both onsite and within a 4-mi radius of the site and are discussed in Sections 3.3.2. The terrestrial sensitive environments within the 4-mi radius also include the North Fork John Day Wilderness Area.

3.3.2 Plant and Wildlife Surveys

Habitat reconnaissance surveys were conducted at the mine sites to establish existing habitat conditions, species composition, and the presence of wetlands and T&E species along Clear Creek and reference/background stations. Prior to conducting the fieldwork, a list of SOC and T&E plant species was generated, obtained from the Umatilla NF (Table 3). In addition, a list of T&E and SOC for wildlife species potentially occurring in Grant County was generated, obtained from the Oregon Natural Heritage Program (Table 1, ONHP 2001). The Oregon Natural Heritage Information Center (ONHIC) was also contacted regarding any specific recorded observations of T&E species and SOC within a 2 mile radius of the sites (the search range available from the ONHP), including any northern goshawk (federal-listed SOC) nests in the project area (Appendix D, OHNIC 2003).

To accomplish the SOC and T&E species surveys, two approaches were used. While assisting with water sampling, sediment sampling, and vegetation sampling, the site was monitored for wildlife. In addition, flora was located for a later timed-meander-search (TMS) procedure. A simple classification, using the National Vegetation Classification System (NVCS), was conducted to determine the habitat types at the mine sites, typically the riparian and forested slopes being the major types (FGDC 1997). All observed species at the site were recorded on a field data sheet as they were encountered and unknown species were collected, preserved, and later keyed for identification using reference materials.

Site Habitat Description and Characterization

The habitat was characterized in the area of the 2 mine sites using the National Vegetation Classification Standards (NVCS) (FGDC 1997), combined with a simple habitat assessment to document dominant plant species observed including canopy and understory species. The following observations of the area were made:

- The mines are located within a large valley ranging from 0.25 to a l mi wide and 1,000 ft deep with extremely steep slopes in many areas. The coniferous forest on the hillside was considered one habitat type and the riparian zone the second. The riparian floor is between 200 and 500 ft wide and is extremely flat in many areas due to past dredge mining practices and recent restoration efforts. The riparian zone was very open and in many places almost devoid of any woody riparian vegetation (Photo 21).

- Clear Creek ranges from 15 to 30 ft wide in the vicinity of the mines (Photo 17) and has undergone major stream engineering, including the installation of riffles/runs and pools as part of the stream restoration project (Photo 32). Both mines are very close to Clear Creek (Photo 20).

- Scattered evergreens occur along the shoreline and conifers are among the mix planted in the restoration areas. The riparian NVCS code varies between a temporarily flooded cold-deciduous shrubland (III.B.2.N.d, Fig. 19) to a more simple temporarily flooded Herbaceous (V.B.2.N.d, Fig. 52) to a hydromophic rooted vegetation subclass (V.C.2.N.a).

Vegetation

There are essentially 2 habitat types in the area of the sites:

- The moderate to steep hillsides along either side of Clear Creek.
- The riparian zone along the valley floor.

The hillsides contained scattered trees, including many large ponderosa pine (*Pinus ponderosa*) and larch (*Larix occidentalis*) snags. The hillsides on drier southern facing slopes are dominated by ponderosa pine and by lodgepole pine (*Pinus contorta*) and the majority of the other slopes are dominated by douglas fir (*Pseudotsuga menziesii*). There were significant numbers of dead trees in many areas and there was evidence of cattle grazing above Blackjack Mine.

Much of the surrounding hillsides are steep; the forest was in poor condition with over 25 percent dead snags in some places. In a few areas of denser cover, those areas could be classified essentially "evergreen forest" (classification IA in the NVCS) and not "woodland" (NVCS Code IIA) by their cover greater than 60 percent. These areas tended to be even age of lodgepole pine indicating recruitment after disturbance from fire, insects, or timber harvest. The hillside forest recruitment is a typical one for the Blue Mountains (Franklin and Dyrness 1973). There is almost a complete absence of understory shrubs on the hillsides with the primary understory being grasses, whortleberry (*Vaccinium* sp.) and scattered forbs (Photo 52). Wild strawberry (*Fragaria virginiana*), the plant species selected for plant tissue collection (see below) was widespread in a variety of habitats, as it was at other sites in the area (EA 2003a, EA 2003b).

Two species of *Carex*, a low northern sedge (*Carex concinna*) and a meadow sedge (*Carex praticola*), were noted in the search (OHNIC 2003). These sedge species are not a Federal- or State-listed species, but are considered sensitive and are not commonly found in the area. No T&E species or SOC on the Umatilla list were observed during the SI. One *Carex* species was commonly observed along Clear Creek. A sample of the plant was collected and sent to Cooke Scientific Services in Seattle for identification. The plant was confirmed by botanists not to be any of the *Carex sp*. included on the Umatilla NF list. The plant species that were observed during the SI are listed on Table 4.

The species observed along the creek were typical of riparian areas, although the area did not support any large stands of cottonwood (*Populus* sp.), willow (*Salix* sp.) or alder (*Alnus incana*); although some sparse willow trees were present in some locations. The vegetation along the creek was generally at the forb stage, with some areas of scrub-shrub (mostly alder). However, some species of fruiting shrubs (such as gooseberry [*Ribes* sp.]) and elderberry (*Sambucus* sp.) were observed, indicating that recruitment of more typical riparian species is occurring. The settling ponds to the west side of Clear Creek (where AMD from the Bluebird Mine discharges) were not surveyed because they are located on private property. These ponds appeared to have healthy vegetation dominated by cattails (*Typha sp*.), grasses and sedges (*Carex* sp. and *Scirpus* sp.), and little open water. The side channel located between the Bluebird and Blackjack Mines contained the greatest vegetation growth in the riparian zone. This may have been due to the improvements from the restoration project. The deeper slower movement of the side channel allowed the establishment of the some submerged vegetation, including buttercup (*Rannunculus aquatilis*) and some other grass and sedge species.

As part of the habitat restoration project, thousands of trees and shrubs have been planted along Clear Creek. These were planted from at least a mile downstream of the Bluebird Mine up to Blackjack Mine

and a large amount of dredge tailings appear to have been removed or regraded (Photo 15). Open areas away from the creek have been restored to grade in the valley of the creek and planted with ponderosa pine. The seedlings have been covered with plastic mesh to provide protection from browsing. The shoreline and riparian portion of the stream is therefore extremely disturbed, however, assuming survival and growth of the seedlings, will have an excellent riparian cover in the future.

Wildlife

The species observed in the vicinity of the Bluebird and Blackjack Mine sites during the SI are listed in Table 2. No terrestrial T&E species or SOC were identified by the OHNIC within a 2 mile radius of the site. Although, the olive-sided flycatcher was heard on one occasion, as discussed previously in Section 3.2.2. Major rodent burrows in the waste rock material were observed at the base of the Bluebird Mine waste piles (Photo 26) and these species could be exposed to the finer material through inhalation and grooming.

Unlike the Granite Creek and Lucas Gulch sites (EA 2003d, EA 2003e), there were significantly more wildlife observed at the Clear Creek sites, despite the extremely hot weather (above 100 ° F) during the SI field effort, which reduced activity of wildlife. The site also has regular road traffic, which also limited wildlife viewing and the habitat has not recovered from the major restoration activities. It will likely take decades for the intended results of the riparian restoration to be fully achieved. An example of the changes that have occurred as a result of the restoration project is the presence of pikas (*Ochotona princeps*), a small mammal that typically uses talus slopes, in the dredge tailings above Blackjack Mine. The restored area downstream of Blackjack Mine provides no habitat for pikas, since most of the dredge tailings have been removed, and other species will likely move into the area as changes continue to take place.

3.3.3 Sample Locations

Sample locations are presented on Figures 1a and 1b (the northern and southern portions of the Bluebird Mine) and Figure 2 (Blackjack Mine).

3.3.3.1 Soil and Waste Samples

Bluebird Mine

Three surface soil and/or waste samples were collected at the Bluebird Mine during the SI, including:

- Two surface soil samples from the adit discharge area: one from the adit discharge (BLUE-19) behind the bulkhead (where water used to discharge prior to the installation of the drainage pipe) and one from the drainage path downgradient of the adit (BLUE-23).
- One surface soil sample from the former mill area (BLUE-27).
- Note: One surface soil sample was collected from the retention pond area (BLUE-16). However, this sample took on water from the cooler during shipment to the laboratory; therefore, the analysis for this sample was cancelled.

Five subsurface soil and/or waste samples were collected, including:

- One sample was collected downgradient of the retention pond (BLUE-29).

- Two samples were collected at the upper waste pile (BLUE-22 and BLUE-21).
- One sample was collected at the lower waste pile (BLUE-20).
- One sample was collected downhill of the lower waste pile (BLUE-24).
- Note: One sample was collected downhill of the upper waste pile (BLUE-28). However, the sample took on water from the cooler during shipment to the laboratory; therefore, the analysis for this sample was cancelled.

In addition, black-stained soils were observed along the shoreline of Clear Creek at the downstream end of the Bluebird Mine site, north of the dry settling pond. The horizontal band of black soil was approximately 11 in. in depth, at its thickest, and stretched approximately 300 ft in length along a flat area of the shoreline. The black soil was more compacted and brittle than the native soil located above and below it, although the soil characteristics were very similar. In addition, a band of red-stained soil was observed beneath the black layer. Two subsurface soil samples were collected from this area:

- One sample from the black soil layer (BLUE-32) and one from the red soil layer (BLUE-33).

Blackjack Mine

One surface soil sample (Station BLAC-44) was collected at the Blackjack Mine during the SI from the retention pond located downgradient of the upper adit. It should be noted that this sample station was numbered incorrectly in the field and was originally identified as BLAC-10, the same location number as the sample collected in the settling pond downstream of BLAC-15. The sample station was changed to BLAC-44 for reporting purposes.

In addition, a total of 5 subsurface soil and/or waste samples were collected:

- One sample was collected in stained soil area near the mouth of the upper adit (BLAC-12).
- One sample was collected downhill of the mouth of the adit, at the toe of the iron-stained channel leading to Clear Creek (BLAC-14).
- One sample was collected from the large waste pile near the upper adit (BLAC-13).
- One sample was collected downhill of the waste pile, at the toe of the blue-grey colored erosion channel from the waste pile (Station BLAC-31).
- One sample was collected beneath the break in the berm of the retention pond, at the toe of the slope above Clear Creek (Station BLAC-30).

All soil and/or waste samples collected at the Blackjack Mine were analyzed for pH, TAL metals, chromium VI, and cyanide. SPLP and Acid Base Accounting (ABA) parameters were also included as appropriate.

3.3.3.2 Plant Tissue Samples

Plant Tissue Collection

Plant tissue specimens were collected from 4 onsite stations (waste piles) and 2 background stations. The samples were analyzed for Cyanide (USEPA Method 9012) and TAL Metals (USEPA Method 3050/6010B and for mercury, USEPA Method 7471). The 2 background stations were located on the hillsides within the Clear Creek drainage, but outside of the mining activity. There were often only a few plant species available on the waste piles and tailings, and many in very small densities. The targeted plant species, wild strawberry (*Fragaria virginiana*), was chosen because it occurred on the often barren waste piles and it is both browsed by wildlife and its fruit eaten by many organisms. This species also exhibited stressed vegetation signs at the onsite locations. Visual stress indicators included yellow leaves with green veins (which could indicate toxicity or lack of nutrients), leaves with brown tips (which could indicate burning), and stunted growth (as compared to plants in background areas).

While wild strawberry is not the most important browse or fruit species, its prevalence on the waste piles and other locations impacted by mining make it a potentially useful species for future use in a food chain analysis of ecological risks. Another strawberry species that was observed in the area of the sites was *Fragaria vesca.* Speciation of strawberries were difficult to determine without flowers or fruit.

Because there was no Fragaria on the waste pile at Bluebird, the sample was collected on the top of the pile near the adit opening (Photo 24). Similarly, samples were collected at the upper adit at Blackjack Mine (Photo 54). Background samples were collected on the hillsides outside of the mine influence at Bluebird Mine (Photo 10) and Blackjack Mine (Photo 52).

Plant tissue specimens were collected from the following locations and were co-located with the corresponding soil samples:

- Two stations at the Bluebird Mine site (BLUE-20 and BLUE-24).
- Two stations at the Blackjack Mine site (BLAC-11 and BLAC-12).
- Two background areas (CLEA-25 and CLEA-26).

3.3.4 Analytical Results

All soil and/or waste samples collected at the Bluebird Mine were analyzed for pH, TAL metals, chromium VI, and cyanide. SPLP and ABA parameters were also included as appropriate. In addition, the unusual black- and red-stained soil samples discovered at the Bluebird Mine (BLUE-32 and 33) were analyzed for these additional parameters:

- Volatile Organic Compounds (USEPA Method 8260B)
- Semivolatile Organic Compounds (USEPA Method 8270C)
- Diesel-Range Organics (by method NWTPH-Dx Modified)
- Methylmercury (USEPA Method 1630 draft).

Criteria for comparing measured concentrations of metals in soils consisted of the following human health and ecological screening values:

- ODEQ (1998) Guidance for Ecological Risk Assessment, Level II Screening Values.
- USEPA Region 9 PRGs for Industrial Soils (http://www.epa.gov/region09/waste/sfund/prg/index.htm).
- USEPA (2000a) Generic Soil Screening Levels (SSLs), for protection of human health.
- USEPA (2000b) Ecological Soil Screening Levels (EcoSSLs).
- Oak Ridge National Laboratory PRGs for protection of plants, wildlife, or soil invertebrates, U.S. Department of Energy (Efroymson et al. 1997).

Analytical data were compared to the lowest available screening criteria.

All plant tissue samples were analyzed for TAL metals and cyanide. No comparison criteria are available for plant tissue; these data may be used in a food chain model, if required in the future. The plant tissue samples were compared to background samples for discussion purposes.

Surface and Subsurface Soil/Waste Samples

A summary of the surface and subsurface soil/waste samples is provided in Table G-4. Surface and subsurface soil sample analytical results indicated the following:

Background

The following TAL metals were detected above one or more of the comparison criteria in at least one of the background samples:

- Aluminum, arsenic, barium, beryllium, total chromium, copper, manganese, mercury, nickel, selenium, thallium, vanadium, and zinc.

Bluebird Mine

- Aluminum, barium, and beryllium were all detected in at least one background sample at a higher concentration than those detected in the onsite samples at the Bluebird site.
- Antimony, arsenic, total chromium, cobalt, copper, iron, lead, mercury, nickel, selenium, thallium, and zinc were detected in at least one of the 3 surface soil samples collected at the Bluebird site. Of these, antimony, arsenic, iron, lead, mercury, selenium, and thallium were notably above concentrations of those measured in at least one of the background samples.
- Arsenic, total chromium, cobalt, copper, manganese, mercury, nickel, selenium, thallium, vanadium and zinc were detected in at least one of the 7 subsurface samples collected at the Bluebird site. However, only arsenic, total chromium, and manganese were detected at concentrations notably above background levels.
- Overall, it appears that the highest concentrations of metals were detected in the samples collected from the adit, the drainage route from the adit to the stream, downhill from the lower waste pile, and the black and red stained soils.

- The samples collected at stations BLUE-32 and 33 were also submitted for volatile organic compounds, semivolatile organic compounds, total petroleum hydrocarbons, and methylmercury analysis. Of the volatile organic compounds and semivolatile organic compounds, only bis(2-ethylhexyl)phthalate and dichloromethane were detected above the method detection limits. However, bis(2-ethylhexyl)phthalate was also detected in the method blank and dichloromethane is considered a common laboratory contaminant. Motor oil was detected in the sample collected at station BLUE-32 at 35.8 mg/kg. Methylmercury was not detected in either sample.

Blackjack Mine

- Aluminum, barium, beryllium, manganese, and zinc were all detected in at least one background sample at concentrations higher than those in the on-site samples.

- Antimony, arsenic, total chromium, copper, iron, lead, mercury, selenium and thallium were detected in the surface soil sample collected from the retention pond at the site. Of these, arsenic, total chromium, copper, iron, lead, mercury, selenium, and thallium were detected notably above the levels detected in at least one of the background samples.

- Arsenic, total chromium, cobalt, copper, iron, mercury, nickel, selenium, thallium, and vanadium were detected in the subsurface surface soil samples collected at the site. Of these, concentrations of arsenic, total chromium, copper, iron, mercury, nickel, selenium, and thallium were detected notably above those measured in at least one of the background samples.

- In general, the majority of the highest concentrations were detected in samples BLAC-30 (collected downhill of the retention pond overflow channel) and BLAC-13 (in the waste pile above the erosion channel).

Plant Tissue Samples

A summary of the plant tissue analytical data is provided in Table G-5. For most metals, concentrations detected in the onsite plant tissue samples fell within the range of background. Metals detected at concentrations exceeding the range of background in plant tissue samples included:

- Iron, magnesium, and zinc in sample BLAC-11, collected at the lower adit. Cyanide was also detected in this sample above the method detection limit (at 2.9 mg/kg). In the co-located sediment sample at this location, cyanide was not detected above the method detection limit and iron and magnesium were not elevated above the comparison criteria. However, zinc was detected in the sediment sample at a concentration notably above the comparison criteria.

- Aluminum, iron, and mercury in sample BLUE-20, collected from the lower waste pile.

- Aluminum, iron, and zinc in sample BLUE-24, collected downhill from the lower waste pile.

All of the metals detected in the plant tissue samples were also detected above the comparison criteria in the colocated soil samples (BLUE-20 and 24), although for most metals, the results were either comparable to or below the background sample concentrations.

3.3.5 Soil Exposure Pathway Summary

Bluebird Mine

There is evidence of releases of site-related constituents to soils at the Bluebird Mine site.

- A number of metals were detected in onsite surface soil samples at concentrations exceeding comparison criteria. Although background surface soil samples also exceeded comparison criteria for a number of metals, the following metals in onsite samples were detected both at concentrations exceeding the comparison criteria and at concentrations notably above background; antimony, arsenic, total chromium, cobalt, copper, iron, selenium, thallium, vanadium, and zinc.

- Several localized areas of very high concentrations of metals were found in surface soil/waste samples; more may be present at the site. The samples with the highest concentrations were collected at the adit, the drainage route from the adit, and the black and red stained soils.

- Erosion of fine-grained waste material and soil was evident at the site, both along the channel downgradient of the adit and on the waste rock slopes. These eroded waste materials and soil would enter Clear Creek during periods of high rainfall and snowmelt.

- A localized area of motor oil was detected in subsurface soil samples (stained black) collected along the shoreline at the Bluebird site. The source of the motor oil contamination is not known and the extent was not completely defined.

- No listed terrestrial species have been reported in the vicinity of the site (ONHIP 2003), however, the olive-sided flycatcher (*Contopus cooperi*) was heard calling on the hillside in the general area of the mine during the SI. The physical disturbance of the mine site area appears to have reduced the quality of habitat available to potential wildlife species, but undisturbed, suitable habitat is available in the areas surrounding the mine site.

Blackjack Mine

There is evidence of releases of site-related constituents to soils at the site.

- A number of metals were detected in onsite surface soil samples at concentrations exceeding comparison criteria. Although background surface soil samples also exceeded comparison criteria for a number of metals, the following metals were detected both at concentrations exceeding the comparison criteria and at significant concentrations compared to background ; antimony, cobalt and lead.

- The majority of the highest concentrations were detected in the erosion channel coming from the large waste pile.

- Erosion of fine-grained waste material and soil was evident at the site. These areas were downgradient of the retention pond, along the erosion channels both from the adit and the large waste pile, and on the steep waste rock slopes. These eroded waste materials and soil likely enter Clear Creek during periods of high rainfall and snowmelt.

- No listed terrestrial species have been reported in the vicinity of the site (ONHIP 2003), however, the olive-sided flycatcher (*Contopus cooperi*), a Federal-listed SOC, was heard calling on the hillside in the general area of the mine during the SI. The physical disturbance of the mine site area appears to have reduced the quality of habitat available to potential wildlife species, but undisturbed, suitable habitat is available in the areas surrounding the mine site.

3.4 AIR PATHWAY

Although air samples were not collected as part of this SI, the following information was collected:

3.4.1 Targets

The target distance for air has been defined as a 1 and 4 mi radii from the site. It is estimated that 50 people live within 4 mi of the sites. The shortest distance from any potential sources of contamination onsite to any residence or regularly occupied building is estimated to be approximately 0.5 mi from the Bluebird Mine and 1.4 mi from the Blackjack Mine. It is estimated that there are 4 residents within 1 mi of the Bluebird and Blackjack Mine sites.

There were few wetlands identified on the wetland maps within a 4 mi radius of the mine sites, due to the mountainous habitat surrounding the sites. It is estimated that less than 1 percent, or 320 acres, of the area within 4 mi of the sites are characterized as wetlands (USFWS 1994). In the immediate vicinity of the mines, there are few other wetlands. Other sensitive environments located within 4 mi of the sites are indicated in Section 3.3.1.

3.4.2 Air Pathway Summary

The most likely air pathway at the mine sites is through inhalation of particulate matter. No metals were detected in surface soil samples at a concentration exceeding the available USEPA soil screening level for inhalation of particulates at either site; however, several metals were detected at concentrations which were notably above the highest background concentration. For the Bluebird site, these include antimony, arsenic, iron, lead, mercury, selenium, and thallium. For the Blackjack site, these include arsenic, total chromium, copper, iron, lead, mercury, selenium, and thallium. Therefore, the potential for an observed release to air is considered complete, however, the likelihood of exposure from dust particles is low. Because the air pathway is directly related to the soil exposure pathway, addressing and/or eliminating contaminated soils at the site would likely render the air pathway incomplete.

4. SUMMARY AND CONCLUSIONS

The following site characteristics and conclusions have been identified, based on site observations and the results of field and laboratory analyses:

Bluebird Mine

Groundwater Pathway:

- Groundwater is not used for drinking water within the 4-mile target distance limit; therefore, the groundwater pathway appears to be incomplete. Any impacted shallow groundwater at the site is expected to be very localized in nature, and to present a risk to nearby surface water bodies, in the form of springs and seeps.

Surface Water Pathway:

- Based on analytical results, metals from the Bluebird mine do not appear to be impacting surface water in Clear Creek.

- There is evidence of a release of metals to the surface water in the settling pond (which receives adit drainage through a pipeline) on the west side of Clear Creek. Based on the analytical results of downstream samples collected in Clear Creek, it does not appear that contamination from the ponds has impacted surface water in Clear Creek.

- Based on the macroinvertebrate data, it does not appear that the benthic community is being impacted by the site. The overall score at pool Station BLUE-06, the first downstream station, was lower compared to the reference station and locations further downstream. However, the 6-point decrease in the score at this location is not statistically significant.

- One of the fish species observed at the first downstream sample location (Station BLUE-06) and at the reference location after the spill (BLUE-05) are thought to be either inland/interior redband trout or westslope cutthroat trout. These species are both federal-listed SOC and identified as a vulnerable species by the Oregon Fish and Wildlife Commission. These fish may be impacted by mine discharges.

Soil Exposure Pathway:

- A number of metals were detected in surface and subsurface soil samples at concentrations exceeding comparison criteria. Overall, the highest concentrations of metals in soil and waste samples were detected in the samples collected from the adit, the drainage route from the adit to the stream, downhill from the lower waste pile, and the black and red stained soils.

- Petroleum contamination, at low concentrations, was detected in subsurface soil along the creek. The source and extent of this contamination is not known.

- The site includes a large amount of waste rock and contaminated soil from AMD that periodically discharges from the adit though a channel to Clear Creek. Erosion of fine-grained waste material and soil was evident at the site, both along the channel from the adit and from the waste rock

slopes. These eroded waste materials and soil would enter Clear Creek during periods of high rainfall and snowmelt.

- There is a significant potential for future overflows from the adit, due to the current construction of the pipe drainage system and its history of periodic failure. Such an event would allow the discharge of large volumes of AMD, sediment and flocculent with very high metals concentrations to enter Clear Creek. It should be noted that the pipe discharge system is currently being replaced by the Forest Service.

Air Pathway:

- The air pathway is considered complete, as several metals were detected in surface soil samples at concentrations notably above background. However, because the air pathway is directly related to the soil pathway, reducing or eliminating contaminated soils at the site would likely render the air pathway incomplete. Further assessment of the air pathway is not considered necessary .

Blackjack Mine

Groundwater Pathway:

- As discussed in the Bluebird mine summary.

Surface Water Pathway:

- Based on analytical results, there is no evidence of a release of metals from the mine site to surface water in Clear Creek. However, observations of the site and the creek (iron flocculent and staining), as well as the aquatic survey results, indicate the Blackjack Mine site may impact Clear Creek during spill events.

- The pore water and sediment in Clear Creek appears to be slightly impacted by contamination potentially migrating from the site, although the impact to pore water appears to be minimal in comparison to the reference sample. A number of metals were detected in the sediment samples at concentrations exceeding the comparison criteria and the reference sample concentrations, and the impact appears to be most notable at station BLAC-02.

- There is evidence of a release of metals to the surface water in the settling pond (which receives adit drainage) on the east side of Clear Creek. The contamination in the pond does not appear to be impacting the surface water quality in Clear Creek.

- There is a likelihood for future overflows from the adit, due to the current configuration of the piping system, which impedes proper maintenance and has a history of periodic failure. Such an event would discharge large volumes of AMD, sediment and flocculent with very high metals concentrations to Clear Creek, as evidenced during the most recent spill incident.

- One of the fish species observed in the seines during the SI (BLAC-01, 04, and 41) and after the spill (BLAC-01, 02 and 03) are thought to be either inland/interior redband trout or westslope cutthroat trout. These species are both federal-listed SOC and identified as a vulnerable species by the Oregon Fish and Wildlife Commission. These fish may be impacted by mine discharges.

Soil Exposure Pathway:

- A number of metals were detected in surface and subsurface soil samples at concentrations exceeding comparison criteria. Overall, the highest concentrations of metals in soils and waste rock samples were detected in the samples collected downhill of the retention pond overflow channel and in the waste pile above the erosion channel.

- The site includes a large amount of waste rock and contaminated soil from AMD that periodically discharges from the adit though a channel to Clear Creek. Erosion of fine-grained waste material and soil was evident at the site, both along the channel from the upper adit, the channel from the large waste rock pile, and the waste rock slopes. These eroded waste materials and soil would enter Clear Creek during periods of high rainfall and snowmelt, as well as during spills that result from failure of the pipe discharge system.

Air Pathway:

- See Bluebird Mine summary.

Blackjack Spill

- Based on the analytical results, Clear Creek was not significantly impacted by the Blackjack spill. However, the samples were collected 10 days after the spill and some short-term impacts may have occurred prior to sample collection.

- The reduction in certain metric scores for benthic macroinvertebrate communities at Station BLAC-02, as well as a reduction in the index score compared to prior to the spill suggests that the spill had an adverse effect on the communities at this station in the pool habitat. This may have been the result of the large extent of flocculent iron precipitate observed downstream from the mine site to station BLAC-03.

- The effects of the mine spill on the benthic macroinvertebrate communities downstream from the spill were localized, being apparent at downstream pool Station 02 only.

Recommendations

Based on elevated levels of metals detected in on-site soils and waste rock material, in surface water discharging from the adits, and in the surface water and sediment in the settling ponds, EA recommends performance of an Engineering Evaluation/Cost Analysis (EE/CA) at both the Bluebird Mine and Blackjack Mine sites. As part of the EE/CA, a risk evaluation should be performed to assess the human and ecological impacts, establish site removal cleanup standards, and evaluate remediation technologies.

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