Site Inspection
Ajax and Magnolia Mines
Umatilla National Forest, Oregon

Prepared for

U.S. Department of Agriculture–Forest Service
North Fork John Day Ranger District
Umatilla National Forest
Pendleton, Oregon 97801

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LIST OF ACRONYMS

ABA	Acid Base Accounting
AMD	Acid mine drainage
APA	Abbreviated Preliminary Assessment
bgs	Below ground surface.
BLM	(U.S.) Bureau of Land Management
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
HRS	Hazard Ranking System
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
SARA	Superfund Amendments and Reauthorization Act
SI	Site Inspection
SOC	Species of Concern
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
XRF	X-Ray Fluorescence
Yds^3	Cubic yards

EXECUTIVE SUMMARY

A Site Inspection (SI) was performed at the Magnolia Mine and Ajax 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.

These abandoned mine sites are located within 0.2 mi from one another adjacent to Lucas Gulch, which is located within the Granite Creek watershed. The Magnolia Mine, upstream from Ajax Mine, consists of 2 vertical shafts, 2 adits with collapsed portals, 2 adits with intact portals, 5 waste rock piles, 2 settling ponds, and a former stamp mill. The 2 intact portals are located on opposite sides of the creek and both were discharging Acid Mine Drainage (AMD) during the SI. AMD from the east adit drains through a ditch and then through a pipe to the settling pond. There is an outlet pipe from the settling pond to the creek, which is located at the top of the pond. The AMD collects in the pond then drains to the creek once the pond fills to the level of the outlet pipe. AMD from the west adit forms a marshy area, then drains into the creek.

The Ajax Mine is on the east side of Lucas Gulch and consists of 1 upper adit with a collapsed portal, 1 lower adit with an intact portal, 1 settling pond, and 2 waste rock piles. The adit with the collapsed portal was dry during the SI. The adit with the intact portal drains AMD through a pipe under the road to the settling pond. The settling pond then discharges through a marshy area to 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. Results of the SI indicated the following:

- A number of metals was detected at concentrations above the comparison criteria in the water samples collected from potential sources at both the Magnolia and Ajax Mine sites, including the adits and retention ponds.

- Both sites include waste rock piles and contaminated soil from AMD. Erosion of fine-grained waste material was evident at both mine sites adjacent to the waste piles along Lucas Gulch.

- A number of metals was detected in surface and/or subsurface soil/waste rock samples at concentrations exceeding comparison criteria at both mine sites.

- There is evidence of an ongoing release of arsenic from sources at the Magnolia Mine to surface water in Lucas Gulch. Based on the results, arsenic is migrating downstream from the Magnolia site to the onsite stream station at Ajax Mine. The results suggest that there is not an ongoing release of metals from potential sources to surface water at the Ajax Mine. Sediments in the vicinity of both the Magnolia and Ajax Mine sites are being impacted by erosional sources at the sites.

Based on the results of the SI, performance of an Engineering Evaluation/Cost Analysis (EE/CA) is recommended at the Magnolia Mine and Ajax 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 United States Department of Agriculture, Forest Service (Forest Service) at the Magnolia and Ajax Mine sites, located in the Umatilla National Forest 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 Magnolia and Ajax 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 Magnolia and Ajax Mines from 17 to 19 July 2003. 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 (Appendix C), copies of supporting information (Appendix D), aquatic and terrestrial species tables (Appendix E), a detailed wetlands description (Appendix F), aquatic survey results summary tables (Appendix G), waste pile calculations (Appendix H), soil sample descriptions (Appendix I), and laboratory analytical reports (Appendix J).

2. SITE DESCRIPTION, OPERATIONAL HISTORY, AND WASTE CHARACTERISTICS

2.1 DESCRIPTION AND LOCATION

The locations of the Magnolia and Ajax Mines are shown on Plate 1. Both mines are accessed from County Road 73 and Forest Service (FS) Road 580, which is restricted by a locked gate. Just up the road from Ajax Mine is a second locked gate providing access on FS Road 580 to Magnolia Mine. Information regarding the waste pile calculations is provided in Appendix H.

Magnolia Mine

The Magnolia Mine is located approximately 3.5 mi (areal distance) north of the town of Granite, in Grant County, Oregon. The site is situated on flat to moderate slopes adjacent to Lucas Gulch within the Granite Mining District. The site is included on the Granite Quadrangle USGS 7.5-minute topographic map (1995). The location description for the site is:

- Latitude 44° 51’ 32”N
- Longitude 118° 24 08”W
- Section 22, Township 8 South, Range 35.5 East.

The mine is located on Lucas Gulch, approximately 0.2 mi upstream from the Ajax Mine. The site covers an area of approximately 1 acre, and consists of 8 active claims conducting occasional assessment and maintenance activities (USDA 2002). A map showing existing site features is presented as Figure 1. The site consists of the following:

- Four adits, 2 of which are collapsed and 2 are intact and discharging AMD. One of the collapsed adits is located on the east side of Lucas Gulch at approximately 5,400 ft in elevation. The other collapsed adit is located near the southern end of the site just on the east side of the FS Road 580. One of the intact adits is located on the east side of the creek at approximately 5,300 ft in elevation (referred to hereafter as the “eastern” adit). The discharge flowing from this adit empties into 2 settling ponds in series, which then drain into Lucas Gulch. The mine discharge flows from this adit to the first settling pond through an open ditch approximately 100-125 ft in length. This ditch is stained a heavy red color. The other intact adit (boarded up) is located on the West Side of Lucas Gulch (referred to hereafter as the “western” adit). This adit discharges mine drainage as well, which flows directly into Lucas Gulch. The drainage was only slightly stained (red) at the mouth of the adit and virtually clear at its point of entry into Lucas Gulch approximately 15-20 ft from the adit mouth.

- Two settling ponds in series receiving discharge water from the east adit. The upper pond is approximately 30 by 60 ft in size and the lower approximately 20 by 50 ft in size. Both ponds were generally rectangular. The upper pond drains into the lower pond through a pipe and the lower pond is engineered to drain into Lucas Gulch through a 10-12 in. steel culvert. No drainage was discharging from the lower pond during the SI because it was simply infiltrating at the point of entry into the lower pond. During the SI, backhoe tracks were evident in both ponds. The lower settling pond appeared to have been recently drained and the sediment excavated. A portion of the sediment appeared to have been dumped in the upper settling pond. However, there were only small areas of excavated sediment suggesting most of the sediment had been removed from the immediate vicinity. There was an approximate 1 ft layer of red sediment in the undisturbed portion of the lower pond. The height of the lower pond from bottom to the top of

the berm was approximately 6 ft. The water mark indicated a previous water depth of approximately 3 ft.

- A small wooden cabin is situated east of Lucas Gulch and north of the eastern adit. It is not occupied, but is apparently used for storage by claim workers.

- Five waste rock piles were identified at the site, although the edges of the piles could not be clearly delineated. It appeared that a great deal of the waste rock had been moved around and that the ponds had been constructed with waste rock material. Five waste piles were identified at the site, and are discussed from north to south (Figure 1):

  — The largest waste pile (1,171 yds^3), located near the upper east portal.

  — One waste pile (45 yds^3) near the creek at the northern end of the site in the riparian zone. This pile was located adjacent to Lucas Gulch.

  — One small pile (13 yds^3), downgradient of the lower east portal.

  — One pile (188 yds^3), in the riparian zone near the settling ponds. The settling ponds appeared to be constructed in the waste rock.

  — One small pile (8 yds^3) located on the west side of FS Road 580 near the southern end of the site, also in the riparian zone.

Ajax Mine

The Ajax Mine is located approximately 3.3 mi (areal distance) north of the town of Granite, in Grant County, Oregon. The site is situated on moderate to steep hillsides adjacent to Lucas Gulch within the Granite Mining District. Lucas Gulch flows into Granite Creek approximately 0.5 mi west of the site. The site location is included on the Granite Quadrangle U.S. Geological Survey (USGS) 7.5-minute topographic map (1995). The location description for the site is:

- Latitude 44° 51’ 25”N
- Longitude 118° 24’ 16”W
- Section 22, Township 8 South, Range 35.5 East.

The site covers an area of approximately 1 acre, and is currently inactive. A map showing existing site features is presented as Figure 2. The site consisted of the following:

- A total of 4 adits are located at the site. Two of the adits are located on the Ajax No. 2 claim, one on the Ajax No. 1 claim, and another on the Snowbird claim (Koch 1959). Refer to Appendix D for claim locations.

- One adit is located in the riparian zone of Lucas Gulch and discharges AMD through a polyvinyl chloride (PVC) pipe under Forest Service Road 580, and into a narrow settling pond (approximately 4 ft by 10 ft in size). Another adit, which is collapsed, is located approximately 100 ft upgradient and to the northeast. The other 2 adits are reportedly located further uphill; however, these adits could not be located during the SI. It is not known whether the adit portals are still intact or if they are discharging AMD.

- A settling pond constructed on top of a waste rock pile, located within the riparian zone of Lucas Gulch. Heavy staining indicates that the pond has historically breached and overflowed directly into the creek.

- Two waste rock piles; one located near the collapsed portal (134 yds^3) and one on a relatively flat slope in the riparian zone of Lucas Gulch (375 yds^3). Water seeps from the toe of waste pile in the riparian zone (near sample location AJAX-08) and drains into Lucas Gulch. The soil and rocks in this area are stained a red color.

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 equipment. Numerous dredge tailings piles are still visible along these creeks (USDA 2002).

Magnolia Mine

A list of the known historic owners and operators of the Magnolia Group (USFS 2003), as well as the claim locations (Koch 1959), are provided in Appendix D. The following is a brief summary of the history of the site:

- 1895 through 1899 - Seven lode claims were located for the Magnolia group, consisting of Magnolia, Jupiter, Tacoma, Rose, Atlas, Helena, and Violet. All of these claims were maintained until 1996, and through a series of complex location amendments, transfer deeds, and sheriff's sales, there were a number of individual and 4 mining companies in ownership in 1996.

- 1896 - A ten-stamp millsite was located; however, one report states that the millsite claim was not maintained beyond its original location date (USFS 2003). Another document states that a ten-stamp mill was erected in 1899, and a very small amount of ore was extracted until approximately 1904 (Koch 1959).

- 1916 – The property was reported to be idle by this date; however the new owners were planning mill and mine activities. Part of their plans included an addition of a cyanide plant. It is unknown whether this or any other mining activities took place at this time.

- 1920's – Tunnel work reportedly resumed, however, no production records could be located (USFS 2003).

- 1930's through 1990's – Records indicate some tunnel repair work took place.

- 1965 through 1974 - A second set of lode claims were located at Magnolia in 1965, using the same claim names and locations by another set of owners (Harold Sipp et. al.). This second set of claims was worked by the new owners; however, no deeds exist showing the transfer of these claims.

- 1974 through 2002 - The second set of claims were worked by both sets of owners at the same time from 1974 until 1996. Both filed affidavits with Grant County and the U.S. Bureau of Land Management (BLM) during this time. The second set of claims was dropped in 1999; however the second set of owners relocated 4 of the claims in 2002 and have properly maintained them with Grant County and the BLM since.

Ajax Mine

The Ajax group of mining claims consisted of the Golden Star, Snowbird, Vigilant, Ajax No. 1, Ajax No. 2, the Ajax millsite, and the Snowbird Fraction (later Snowbird No. 2). A list of the known historic owners and operators of the Ajax Mine (USFS 2003), as well as the claim locations (Koch 1959), are provided in Appendix D.

Golden Star Claim:

- 1895 through 1902 - The Golden Star claim was located in 1895. The claim changed hands several times between 1898 and 1902 as individual owners sold percentages of their interests.

- 1902 - There were 6 owners with various percentages of undivided interests, and by 1912 that had declined to four, though not all were the same as in 1902.

- 1916 through 1951 - There were 2 owners registered, Finlay McDonald and J.J. O'Dair, in 1916. This ownership share was maintained until 1951, ten years after O'Dair's death. At that time, O'Dair's trust dissolved and his 50% ownership was transferred to his widow, and eventually his children (USFS 2003).

Remaining Claims:

- 1989 through 1935 - The remaining claims in the Ajax group were located between 1989 and 1902. These claims also changes hands several times, until 1917 when William Lachner and J.J. O'Dair became equal owners. They maintained that ownership until 1935 when William Lachner sold all of his interest to J.J. O'Dair.

Ajax Mill Site:

County records indicate that a mill did exist on this mill site, however, no historic records could be located that indicated there was any production from this mill. Records indicate that the following construction activities took place: construction of an ore bin, a road to the ore bin, mill building and tressle repairs, and construction of a tramway. Parts of a remaining tramway were observed near the lower adit during the SI field activities (Figure 2); however, remains of the mill site near Lucas Gulch could not be located.

- 1916 through 1935 - The Ajax Mill Site was located at the mouth of Lucas Gulch on Granite Creek in 1916, and was sold to William Lachner in 1917. Lachner subsequently sold it to J.J. O'Dair in 1935.

- 1993 – The mill site was formally abandoned by J.J O'Dair's daughter, Rosemary Guinn Burton.

Records indicate that a mill structure existed on the Ajax No. 2 claim and that there was some production between 1905 and 1906, likely from this mill (USFS 2003).

The remaining claims in the group were located between 1898 and 1902. They also changed hands several times until 1917, when William Lachner and J.J. O'Dair became equal owners. This arrangement lasted until 1935 when Lachner sold all of his interest to O'Dair. According to the BLM, all of the claims, including the Golden Star, lapsed in 1996 (USFS 2003).

The five-stamp Ajax millsite was located in 1916 at the mouth of Lucas Gulch on Granite Creek. It was sold to William Lachner in 1917, who subsequently sold it to J.J. O'Dair in 1935 with all his other interests. It was maintained until 1993, when it was formally abandoned by Rosemary Guinn Burton, the daughter of J.J. O'Dair (USFS 2003).

Proof of Labor certificates from 1951 indicate that activities on the mill consisted of building and trestle repairs, ore bin construction, construction of a road to the ore bin, and construction of a tramway. There are no historic references concerning production quantities from this mill (USFS 2003), although records do indicate that $40,000 in gold and silver was extracted between 1905-1906 (USFS 2002a). This may have occurred from an earlier version of the mill however, since it was located in 1916.

The Ajax group includes 4 portals. The main one is approximately 500 ft long and is located along Lucas Gulch, with a lesser, collapsed adit located approximately 100 ft upgradient to the northeast. The remaining 2 are located further uphill, 1 on the Ajax No. 1 claim and 1 the Snowbird claim (Koch 1959).

Waste Characteristics

There can be a variety of mine waste problems, with the most difficult one to address being AMD. AMD results from both surface and underground mine workings, waste and tailings piles, and settling ponds. Except for tailings, all are present at the Magnolia and Ajax Mine (Durkin, Herrmann 1994).

In the presence of oxygen and water, 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 effected by the low pH and high metal concentrations in the water. (Durkin, Herrmann 1994)

2.3 PREVIOUS INVESTIGATIONS

Magnolia Mine

The U.S. Environmental Protection Agency (USEPA) performed SIs of 12 mine sites located within the Granite Creek Watershed in October 1996 (USEPA 1997a). The Magnolia Mine was a part of this investigation. Seven sample locations were selected and surface water and sediment samples collected at each of them. The locations were at the lower adit portal, the western adit portal, in each of the settling ponds, and at upstream, onsite, and downstream locations on Lucas Gulch.

All the samples were analyzed for metals and evaluated against media-specific screening guidelines. Four sediment sample 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 1997b). Twelve metal analytes detected in the sediment samples exceeded at least one of the four guidelines. These included arsenic, cadmium, copper, chromium, cobalt, lead, magnesium, manganese, mercury, nickel, selenium, and zinc. In the surface water samples, only arsenic exceeded the guideline concentrations.

The Forest Service conducted an Abbreviated Preliminary Assessment (APA) of the Magnolia Mine in 2002. 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 APA was performed in accordance with the guidelines provided by CERCLA.

During the APA, a visual inspection was conducted and samples from waste piles were field analyzed using a Niton 700 series X-Ray Fluorescence (XRF) spectrum analyzer. Arsenic was the only metals analyte found to exceed USEPA Region 9 Preliminary Remediation Goals (PRGs). AMD was observed flowing from the lower adit through a ditch into 2 settling ponds in series, and then into Lucas Gulch (USFS 2002b).

Ajax Mine

The 1996 USEPA SI for the Granite Creek Watershed also included the Ajax Mine. Sediment and surface water samples were collected from 5 locations consisting of the adit portal, the settling pond, and upstream, onsite, and downstream locations on Lucas Gulch.

The samples were analyzed for metals, and the same guidelines for both sediment and surface water were used (USEPA 1997a). In the sediment samples, 13 metal analytes exceeded one or more of the guidelines. These included arsenic, cadmium, cobalt, copper, cyanide, lead, magnesium, manganese, mercury, nickel, selenium, silver, and zinc. In the surface water samples only arsenic exceeded evaluation guidelines.

The Forest Service conducted an APA at Ajax Mine in 2002 for the same reasons an APA was conducted at the Magnolia Mine. The Ajax Mine APA also included using a Niton XRF spectrum analyzer to field analyze samples from the waste pile. The results indicated that arsenic and iron exceeded USEPA Region 9 PRGs (USFS 2002a).

No other type of sampling was conducted, but the APA also documented the existence of AMD flowing from the adit into Lucas Gulch via a settling pond, which is within the floodplain of the gulch (USFS 2002a).

Environmental Impact Statement (2002)

In 2002, the Forest Service also conducted an Environmental Impact Statement (EIS) on Granite Area Mining Projects, including the Magnolia and Ajax 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 Plan of Operation for the Magnolia site, which was evaluated by the Forest Service under the EIS, involved occasional maintenance and assessment work. The equipment to be operated consisted of a backhoe, small cat, one-yard loader, air compressor, pick-up truck, and hand tools. Fuels would be stored out of the flood plain, and the small cabin on site would be used for storage.

The EIS evaluated water quality and fish and aquatic habitat as two key issues, and then compared the effects of three alternatives on these key issues. No sampling was conducted during the EIS, but the Upper Granite Creek drainage was evaluated on the two key issues as a part of the larger watershed. (USDA 2002).

3. PATHWAY AND ENVIRONMENTAL HAZARD ASSESSMENT

3.1 GROUNDWATER PATHWAY

3.1.1 Geology

The Magnolia and Ajax Mines occur in the Granite Mining District, within the Elkhorn Mountains area of the Blue Mountains geomorphic province. The lode mines of the Granite District lie along the southwestern edge of the Bald Mountain batholith, a large granodiorite body of Jurassic-Cretaceous age with an outcrop area of more than 170 square mi. The principal lode mines occur in a northeast-trending belt of veins and mineralized shear zones about 2 mi wide and 5 mi long (Brooks and Ramp 1968). The veins occur primarily in older argillite of the Elkhorn Ridge Argillite, but a few cut the granodiorite of the batholith. With very few exceptions, the veins of the Granite District strike northeast and dip steeply either east or west.

Production at the Magnolia Mine was from quartz lenses and stringers in a zone of crushed and locally silicified argillite (Brooks and Ramp 1968). The Magnolia vein reportedly averages 4.5 ft in width and occurs at a strike of N 60^{o} E and dip of 70^{o} SE. At one point within the lower tunnel, the vein is offset 17 ft to the north by a cross-fault. Based on the occurrence of the quartz vein within this area, the faulting occurred during or before mineralization (Koch 1959). Sulfides present include pyrite, arsenopyrite, and marcasite. According to Brooks and Ramp (1968), about 15-20 percent of the gold occurred as free gold. Koch (1959) describes the Magnolia Mine as consisting of an adit extending approximately 1,050 ft with a portal near the level of Lucas Creek, and shorter adits and pits on the hillside northeast of the creek. According to Brooks and Ramp (1968), of the 3 adits at the mine, the lowest and longest extended approximately 1,000 ft and reached 280 ft below the outcrop.

Production at the Ajax Mine was from 2 shear zones, 1 in. to 5 ft thick and composed of brecciated argillite containing thin seams of quartz and calcite (Brooks et al. 1982). A small amount of pyrite is present. The Ajax vein occurs at a strike of about N 70^{o}E and dip of 47^{o} to 63^{o} SE. The intersecting Snowbird vein strikes about N 10^{o} E and dips westerly. The Ajax vein was developed by drifts on 3 levels, and the Snowbird vein was developed by drifts on 2 levels (Koch 1959). The primary production reportedly occurred from a 90-ft shoot on the Ajax vein (Koch 1959).

3.1.2 Hydrogeology

No discussion or documentation of groundwater conditions at the site or in the site vicinity were 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. Localized shear zones and faults may also control groundwater flow to some extent. Shallow groundwater in the site area likely flows into Lucas Gulch.

No groundwater samples were collected during the SI; however, water samples were collected from the discharges at 2 adits at the Magnolia Mine and from 1 adit at the Ajax 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. One well is located within a 4 mi radius of the sites, based on a search of the Oregon Water Resources Department database (OWRD) for

water wells (OWRD 2003). According to OWRD records, this well was installed in 1994 for a town of Granite resident. First water reportedly was encountered at a depth of 24 ft during drilling. The well was completed to a depth of 340 ft and the static water level, as measured upon well completion, was 22 ft. The well, located approximately 3.25-3.5 mi (areal distance) from the sites, is used for domestic purposes (OWRD 2003). There are no wellhead protection areas within a 4-mi radius of 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. The use of groundwater for drinking water within the target area is limited to 1 well, located between 3-4 mi from the sites. Considering the depth of the well and the distance from the sites, it is very unlikely that this well 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 Lucas Gulch, approximately 0.5 mi above the confluence with Granite Creek. From the confluence point, Granite Creek flows approximately 14.4 mi to the confluence with the North Fork John Day River.

The Granite Creek watershed encompasses approximately 120-150 square mi (Weston 1997), 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 in. in the lower valleys to 45 in. in the mountains (Brooks et. al. 1968). In the study area, annual rainfall is roughly 30 in., 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 hydrology near the mine sites:

- **Magnolia Mine.** The discharge flowing from the eastern adit empties into 2 settling ponds in series. The lower of the 2 ponds is engineered to drain into the creek; however, at the time of the SI, the flow was simply infiltrating into the bottom of the pond. The western adit discharges mine drainage directly into Lucas Gulch.

- **Ajax Mine.** AMD from the lower adit drains from the portal through an outflow pipe and into a narrow settling pond. The pond, which is approximately 6 ft deep, is situated on top of a waste rock pile. Seeps located at the toe of the pile flow overland and into Lucas Gulch. The soil along this overland route was humic and not notably stained. The area immediately to the southeast was heavily stained and likely represented a previous overflow or breach event.

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 Lucas Gulch downstream from Ajax Mine 0.4 mi to its confluence with Granite Creek, along Granite Creek 14.4 mi to its confluence with the North Fork John Day River and another 0.2 mi on the North Fork John Day to the end of the TDL. The last 2.4 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 only town along the TDL is Granite, which obtains its drinking water from an improved spring in the area (Weston 1997). 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.

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). In addition to Chinook, Granite Creek supports populations of steelhead trout, redband trout, westslope cutthroat trout, dace, mountain whitefish, and sculpin. Bull trout have also been recorded in the upper headwaters (USDA 2002).

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 and Species of Concern (SOC)
- Wetlands as defined by 40 CFR 230.3.

Prior to conducting the fieldwork, a list of threatened and endangered (T&E) species and SOC potentially occurring in Grant County was generated, obtained from the Oregon Natural Heritage Program (Appendix E, Table E-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 mi radius of the sites (the search range available from the OHNIC (2003).

The aquatic species observed in the vicinity of the Magnolia and Ajax Mine sites during the SI are presented in Appendix E, Table E-2. Two federal-listed threatened species were noted within a 2-mi radius of the project area (the area reported by ONHIC) and may exist in Lucas Gulch: 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 mi of the sites by the ONHIC.

Redband trout (*Oncorhynchus mykiss* sp.) and possibly cutthroat trout were observed in Lucas Gulch during the SI (refer to Section 3.2.4). Bull trout were not observed in Lucas Gulch, but were found along the upper portions of Granite Creek during the SI field investigation conducted in that area prior to the Ajax/Magnolia field investigation (EA 2003d).

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. During the SI, no waterfowl were observed in the vicinity of the sites. The only bird species observed along Lucas Gulch was the American Robin (*Turdus migratorius*), which is a sentinel species often used in ecological risk assessments due to its eating and foraging habits. All the other bird species observed were in the forested hillsides surrounding the sites. Bird species observed during the SI are listed on Table E-2 (Appendix E). Other notable species observed in the vicinity of the sites include:

- Red-tailed Hawk (*Buteo jamaicensis*)
- Hairy Woodpecker (*Picoides villosus*)
- Audubon's Warbler (*Dendroica coronata*)
- Common Raven (*Corvus corax*).

Because it was past the nesting season at the time of the survey, no nesting activity was observed. The time of the year also reduced the amount of songbird activity, although half a dozen species were heard singing in the surrounding forest. All of the species observed could have exposure to contamination from the mines from a variety of sources, through dermal contact with potentially contaminated tailings, water, or sediment, to the ingestion of water, sediment, or prey.

Wetlands Assessment

The National Wetlands Inventory (NWI) 7.5-minute topographic map for the Granite quadrangle (USFWS 1994) was examined and compared to wetlands observed in the project area. For a detailed description of these wetlands and definitions, refer to Appendix F. Lucas Gulch is characterized as *Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded*, along with most of the permanent streams in the area. While this classification generally does not meet the CERCLA definitions of a wetland, the upper and lower reaches of Lucas Gulch are mapped with *Palustrine emergent vegetation and scrub-shrub vegetation* classifications that do. In addition, a number of palustrine ponds are situated on Granite Creek downstream of the confluence with Lucas Gulch. It is estimated that approximately 2 mi of the 15-mi TDL are wetlands, including 1.5 mi on Granite Creek above the Town of Granite.

Onsite wetlands at the Magnolia Mine consisted of the wet meadows at the north end of the site, near the cabin. Based upon the plants observed, these meadows ranged from wet to seasonally-wet fields, and were estimated to be approximately 1,000 ft^2 in size. They are classified as *either Palustrine Emergent Bed Saturated* (PEMB) or *Palustrine Emergent Bed Seasonally Flooded* (PEMC). Onsite wetlands at the Ajax Mine included a small (approximately 75 ft^2) wetland located in the vicinity of the seep at the base of the waste rock pile, near sample location AJAX-08. In addition, a small wetland classified as *Palustrine Scrub Shrub Seasonally Flooded* (PSSC) is located at the confluence of Lucas Gulch and Granite Creek. This area was estimated to be approximately 300 ft^2, but may vary due to periods of drought.

3.2.3 Stream Sampling Locations

Locations of stream samples at the Magnolia and Ajax Mines collected during the SI are indicated on Figures 1 and 2, respectively. Photographs of selected sample locations are provided in Appendix B. The impact of the Magnolia and Ajax Mines in relation to the other potential mines located along Lucas Gulch was evaluated by sampling stream locations above, between, and below the mine sites. Granite Creek was also sampled above and below its confluence with Lucas Gulch in order to measure the contaminant impact of Lucas Gulch on Granite Creek.

Upstream reference site locations for benthic macroinvertebrate and analytical sample collection are intended to provide data from a site not impacted by the Magnolia or Ajax Mines for comparison to data collected within the potentially impacted site. Station MAGN-01 was chosen as an upstream reference site (upstream of the Magnolia Mine) to compare to the stations downstream of the Magnolia and/or Ajax Mines.

Station MAGN-03 was chosen as the reference site for the Ajax Mine site. While inputs from the Magnolia Mine could affect this reference site, it allows an assessment of conditions before the influence of the Ajax Mine site.

Magnolia Mine

The sample locations associated with the Magnolia Mine are presented on Figure 1. One reference location (MAGN-01) and 1 location on Lucas Gulch downstream of the Magnolia Mine site (MAGN-02) were sampled for the SI. In addition, sample stations were also located at the adits and in the settling pond on the east side of Lucas Gulch to document potential impacts and migration of contaminants coming from the adits. The following stations were sampled:

Station ID	Location	Matrices Sampled
MAGN-01	On Lucas Gulch, upstream of Magnolia mining activities.	One surface water sample, 1 pore water sample (pool), and 1 sediment sample (pool habitat)
MAGN-02	On Lucas Gulch, immediately downstream of mining activities and the discharge coming from the adit on the west side of the creek and the settling pond.	One surface water sample, 1 pore water sample (pool), and 1 sediment sample (pool habitat)
MAGN-03	On Lucas Gulch, approximately 125 meters downstream of MAGN-02 and upstream of the Ajax Mine site. This station serves as a downstream station for Magnolia Mine and an upstream (reference) station for Ajax Mine.	One surface water sample, 1 pore water sample (pool), and 1 sediment sample (pool habitat)
MAGN-13	Along the drainage route from the main adit on the east side of Lucas Gulch.	One surface water sample
MAGN-11	In the settling pond which collects AMD from the main adit and discharges to Lucas Gulch.	One surface water sample and 1 sediment sample
MAGN-55	Along the drainage route from the adit located on the west side of Lucas Gulch. The sample was collected as close to the mouth of the adit as possible.	One surface water sample was collected

NOTE: AMD = Acid mine drainage.

Ajax Mine

The sample locations associated with the Ajax Mine are presented on Figure 2. One reference stream location (MAGN-03), and 1 location along Lucas Gulch downstream of Ajax Mine were sampled for the SI. In addition, samples were collected from the adit discharge, the settling pond, and the discharge route from the settling pond to Lucas Gulch. Two samples were also collected from Granite Creek to document contaminant input to Granite Creek from the mine sites upstream of the confluence with Lucas Gulch. One sample was collected from upstream of the confluence and 1 sample from below. The following stations were sampled:

Station ID	Location	Matrices Collected
AJAX-04	On Lucas Gulch immediately downstream of mining activities and the discharge from the settling pond.	One surface water sample, 1 pore water sample (pool habitat), and 2 sediment samples (pool and riffle habitat).
AJAX-07	On the east side of the road along the drainage route from the adit, prior to draining through the culvert that leads under the road.	One surface water sample
AJAX-06	In the settling pond which collects AMD from the adit and discharges to Lucas Gulch.	One surface water sample and 1 sediment sample
AJAX-52	In a marshy area along the drainage route from the settling pond to Lucas Gulch..	One surface water sample and 1 sediment sample
GRAN-53	On Granite Creek, upstream of its confluence with Lucas Gulch and upstream of where the road crosses the creek. This sample location is the reference station on Granite Creek.	One surface water sample, 1 pore water sample (pool), and 2 sediment samples (pool and riffle habitat)
GRAN-54	On Granite Creek, downstream of its confluence with Lucas Gulch. This sample location documents the contribution of contaminants from both the Magnolia and Ajax sites into Granite Creek.	One surface water sample, 1 pore water sample (pool), and 2 sediment samples (pool and riffle habitat)

3.2.4 Aquatic Survey Results

Aquatic surveys were conducted to assess the impact, if any, of the Magnolia and Ajax Mine sites on the benthic macroinvertebrate community, presence of fish species, and habitat quality. Survey results are presented in Appendix G (Tables G-1 through G-3). No significant fish barriers were found within the project area. General stream characteristics are presented in the following table:

Station	Habitat (%)			Dominant Substrate	Water Depth (in.)		Current Velocity (ft/sec)	
	Riffle	Pool	Run		Riffle	Pool	Riffle	Pool
Magnolia Mine								
MAGN-01	40	40	20	Silt/CPOM	NS	6	NS	0.00
MAGN-02	40	40	20	Cobble/Silt	NS	2	NS	0.00
MAGN-03	40	40	20	Gravel/Silt	NS	4	NS	0.03
Ajax Mine								
AJAX-04	70	20	10	Riffle – gravel Pool – silt	0.25-1	1-3.5	0.50	0.03
Granite Mine								
GRAN-53	30	40	30	Riffle – gravel and sand Pool – sand	2	6-7	0.93	0.03
GRAN-54	30	40	30	Sand	3.0-8.5	8-10	1.51	0.08

NOTE: CPOM = Coarse particulate organic matter.
NS = No sample.

Due to the small size of Lucas Gulch and the presence of bull trout (*Salvelinus confluents*), seining was not conducted at any of 4 locations on Lucas Gulch or the 2 on Granite Creek. Instead, the 6 locations were visually inspected for the presence of fish. Over a 4-day period, the following observations were made:

Area	Station No.	*Oncorhynchus* spp.
Magnolia Mine	MAGN-01	1
	MAGN-02	1
	MAGN-03	2
Ajax Mine	AJAX-04	1
Granite Creek	GRAN-53	7
	GRAN-54	4

At least 3 of the specimens observed appeared to be redband trout (*Oncorhynchus mykiss*), while the others were too small to identify to species, but were either redband trout or westslope cutthroat trout (*O. clarki*). Both species are federally listed as SOC and identified as vulnerable species by the Oregon Fish and Wildlife Commission. No other fish species were observed.

Lack of adequate pool habitat restricted benthic sampling in Lucas Gulch to only riffle areas, whereas in the larger Granite Creek, both riffles and pools were sampled. Field sampling and laboratory analysis were conducted in accordance with ODEQ methods (ODEQ 2001). The number and relative abundance of each taxa collected are provided in Tables G-1a, G-1b, and G-1c (Appendix G). The resultant data were evaluated using a multi-metric index developed by ODEQ (2001). Raw data and metric scores for the 10 metrics used by ODEQ are summarized in Table G-2. Examination of the index scores revealed no impacts to the Lucas Gulch or Granite Creek benthic communities from either the Magnolia or Ajax Mines. Specific observations pertaining to the data were as follows:

- Index scores at the sites adjacent to the 2 mines (i.e., Stations MAGN-02 and AJAX-04) were comparable to or higher than at the sites immediately upstream (i.e., Stations MAGN-01 and MAGN-03).

- Index scores, total taxa richness, mayfly richness, and stonefly richness all showed a weak trend of increasing values as one moves from upstream to downstream (i.e., from Station MAGN-01 to Station AJAX-04) in Lucas Gulch. These increases, if real, likely reflect changes in steam size rather than responses to anthropogenic inputs.

- Index scores at the 2 Granite Creek riffle stations were identical indicating that inputs from Lucas Gulch do not adversely affect macroinverebrates inhabiting riffles.

- Index scores at the 2 Granite Creek riffle locations were slightly to moderately lower compared to the Lucas Gulch riffle stations due primarily to noticeably lower scores for the percent tolerant taxa metric and the percent sediment tolerant metric. This suggests that Granite Creek may be carrying higher sediment loads or possibly certain contaminants. More sediment deposition was observed in Granite Creek during the habitat assessment supporting the idea that sediment transport in Granite Creek is high.

- The Index score for pool habitat in Granite Creek was noticeably lower at Station GRAN-54 (score of 24), downstream of the confluence with Lucas Gulch compared to Station GRAN-53 (score of 38) upstream of the confluence.

- This difference, if real, could be the result of several factors: toxic contaminants or high sediment loads from Lucas Gulch, or differences in pool quality between these 2 stations. It is also possible that the difference is not real, being an artifact associated with a one-time sampling effort.

- The fact that the Index scores for riffles in Lucas Gulch were higher than those in Granite does not support the toxicity hypothesis.

- The low index score at Station GRAN-54 coincides with elevated sediment concentrations of certain metals (refer to Appendix G, Table G-3).

Habitat conditions were evaluated at each of the 6 stream stations, in accordance with the methods stated in the project plans; habitat scores are presented in Table G-3. The following habitat conditions were noted:

- Habitat was good to excellent (score of 159-175) at all locations.

- Habitat was marginally better in Granite Creek than in Lucas Gulch due to Granite Creek being deeper, faster, and having less embeddness.

- Habitat does not appear to be limiting to benthic organisms at any of the sampling stations.

3.2.5 Analytical Results

Analytical water quality results for surface water, pore water, and sediment samples are presented in Tables 1, 2 and 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. Total metals concentrations for surface water samples are presented in a summary table in Appendix J, along with copies of the laboratory reports.

Field 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 (Table 2). Field water quality measurements for the surface water and pore water are reported in Tables 1 and 2, respectively.

- Field water quality parameters consisted of: hexavalent chromium, temperature (°C), dissolved oxygen (mg/l), specific conductance ($\mu S/cm^3$), pH (standard units), turbidity (NTU), redox potential (ORP) and current velocity (ft/s).
- The pH values at the adits at the Magnolia Mine site ranged from 7.3 to 8.0. The pH value at the Ajax Mine adit was 7.9. The pH values for the surface water and pore water in Lucas Gulch ranged from 8.4 to 8.7 at the Magnolia sampling stations and 8.1-8.7 at the Ajax sampling stations. The pond samples were also within this range.
- Field water quality measurements did not indicate that these parameters were a limiting factor that 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).

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

- ODEQ Water Quality Criteria, Protection of Aquatic Life, Fresh Chronic Criteria (Oregon Administrative Record [OAR] 340-041-001); hardness-dependent values (cadmium, chromium III, copper, lead, nickel, silver, and zinc) were calculated based on the hardness for each sample, and the range of values is provided in the data tables.

- ODEQ Water Quality Criteria, Protection of Human Health, Water, and Fish Ingestion (OAR 340-041-001).

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

- USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, chronic; hardness-dependent values were calculated separately for each sample.

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

- USEPA (2002) recommended ambient water quality criteria for protection of human consumption of fish; hardness-dependent values were calculated separately for each sample.

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

Of these screening values, comparisons were made with the lowest value available. Results of the metals analyses for surface water and pore water are discussed in the following table and presented in Tables 1 and 2, respectively).

Summary of Surface Water, Pore Water and Sediment Metals Data

Sample Type	Table/ Sample Nos.	Dissolved Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Surface Water	Table 1		
Magnolia – upstream	(MAGN-01)	Barium, mercury and selenium	
Magnolia – east adit	(MAGN-13)	Arsenic, barium, calcium, iron, manganese, nickel, and thallium	Arsenic, calcium, iron, manganese, and nickel were at notably high concentrations.
Magnolia – Pond	(MAGN-11)	Arsenic, barium, calcium, iron, manganese, mercury, and nickel	Of the metals detected above the comparison criteria, calcium, iron, manganese, and nickel were at notably high concentrations. These analytes were also detected at high concentrations in the east adit water sample.
Magnolia – west adit	(MAGN-55)	Barium	Not at a notably high concentration.
Magnolia – at the mine	(MAGN-02)	Arsenic and barium	Arsenic was notably higher than the reference concentration. Barium was at a comparable concentration.
Magnolia – downstream/ Ajax - upstream	(MAGN-03)	Arsenic, barium, and thallium	Arsenic was detected at a notably higher concentration than the reference sample concentration. Barium and thallium were comparable to the reference.
Ajax - adit	(AJAX- 07)	Aluminum, arsenic, barium, iron, lead, manganese, mercury, nickel, and selenium	Aluminum, arsenic, iron, lead, manganese, mercury and nickel were at notably high concentrations.
Ajax - pond	(AJAX-06)	Barium, manganese, and mercury	Manganese was detected at a high concentration and was also detected at very high concentrations in the adit water sample.
Ajax – overland route from waste pile to stream	(AJAX-52)	Arsenic, barium, iron, manganese, and mercury	Arsenic and iron were detected at notably high concentrations. Manganese was detected just above the comparison criteria.
Ajax – at the mine	(AJAX-04)	Arsenic, barium, lead, and mercury	All of the analytes were comparable to the reference sample concentrations (MAGN-03). Arsenic was detected at a concentration notably above the Magnolia reference sample (MAGN-01).
Granite Creek – upstream	(GRAN-53)	Arsenic, barium, and mercury	Barium and mercury were at similar concentrations to the Lucas Gulch reference sample. The concentration of arsenic was notably above the Lucas Gulch reference concentration (MAGN-01), but lower than the downstream sample concentrations on Lucas Gulch.
Granite Creek – downstream	(GRAN-54)	Arsenic, barium, and mercury	The concentrations were similar to the Granite Creek reference sample.
Pore Water	Table 2		
Magnolia – upstream	(MAGN-01)	Barium and mercury	
Magnolia – at the mine	(MAGN-02)	Barium and mercury	The concentrations of both barium and mercury were similar to the reference sample concentrations.
Magnolia – downstream/ Ajax - upstream	(MAGN-03)	Barium and mercury	The concentrations of both barium and mercury were similar to the reference sample concentrations.
Ajax – at the mine Granite Creek – upstream	(AJAX-04) (GRAN-53)	Barium Barium	The concentration was similar to the reference concentration. The concentration was lower than the Lucas Gulch reference sample concentration.
Granite Creek – downstream	(GRAN-54)	Barium and mercury	The concentrations of both barium and mercury were similar to the reference sample concentrations.

Criteria for comparing measured concentrations of metals in sediments consist of the following values:

- 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 (1997) National Sediment Quality Survey, Screening Values for Chemicals Evaluated.

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

Similar to the surface water and pore water samples, the sediment results were compared to the lowest screening criteria available. The analytical results for the sediment samples are provided in Table 3 and are summarized in the following table.

Sample Type	Table/ Sample Nos.	Dissolved Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Sediment	Table 3		
Magnolia – upstream	(MAGN-01)	Nickel	
Magnolia – Pond	(MAGN-11)	Antimony, arsenic, cadmium, copper, manganese, mercury, nickel, silver, and zinc	Arsenic, chromium, copper, manganese, nickel, and zinc were at notably high concentrations.
Magnolia – At the mine	(MAGN-02)	Arsenic, chromium, copper, mercury, and silver	Arsenic, chromium, mercury, and silver were notably above the reference sample concentrations.
Magnolia – downstream/ Ajax – upstream	(MAGN-03)	Antimony, arsenic, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc	Arsenic, lead, manganese, mercury, nickel, and zinc were notably above the reference sample concentrations.
Ajax – Pond	(AJAX-06)	Antimony, arsenic, cadmium, copper, manganese, mercury, nickel, and zinc	Arsenic, cadmium, copper, manganese, mercury, nickel, and zinc were at notably high concentrations. Cadmium, manganese, nickel and zinc were at the highest concentrations of all the sediment samples collected.
Ajax – overland route	(AJAX-52)	Antimony, arsenic, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc	Antimony, arsenic, copper, manganese, nickel, and zinc were at notably high concentrations. Of these, antimony and arsenic were at the highest concentrations of all the samples collected.
Ajax – At the mine	(AJAX-04)	Antimony (p), arsenic, cadmium (p), copper, lead (p), manganese, mercury, nickel, silver, and zinc (p)	Antimony, arsenic, mercury, and nickel were below the Ajax reference concentrations (MAGN-03), but higher than the Lucas Gulch reference concentrations (MAGN-01). The other metals were detected at concentrations which were higher than both the reference concentrations, though not significantly higher. It should be noted that all of the metals detected at concentrations above the comparison criteria in this sample were also detected at elevated concentrations in the overland route sample.
Granite Creek – upstream	(GRAN-53)	Arsenic, cadmium, lead, nickel, silver, and zinc	All concentrations were notably higher (in both pool and riffles) than the upstream reference sample concentrations on Lucas Gulch (MAGN-01).
Granite Creek – downstream	(GRAN-54)	Antimony, arsenic, cadmium, copper, lead, mercury (p), nickel, silver, and zinc	Arsenic, copper, lead, and silver were all higher than the Granite Creek (GRAN-53) and Lucas Gulch reference (MAGN-01) concentrations. Cadmium was just slightly higher than the reference sample concentrations.
NOTE: (p) = Detected in pool only.			

In sediment samples, the percentage of fine material (clay and silt) was higher in the 2 pond samples and in the sample collected along the overland route at the Ajax site. The sample collected at location MAGN-11, at the Magnolia lower pond, was composed of 93 percent fines. The sample collected at AJAX-06, at the Ajax pond, was composed of 86 percent fines and at AJAX-52, along the overland route, was composed of 47 percent fines. Sediments collected from the streambed were coarser and were composed primarily of gravel and sands.

3.2.6 Surface Water Pathway Summary

There is evidence of an ongoing release of arsenic to surface water from the Magnolia Mine site. In the surface water sample collected just downstream of site activities, additional metals detected at concentrations above the criteria included barium and thallium, though they were comparable to the reference concentrations.

Analytical data suggests that there is not an ongoing release of metals to the surface water at the Ajax site. Arsenic was detected at a concentration that was notably higher than the concentration in the surface water sample collected upstream of the Magnolia site, suggesting that arsenic is migrating downstream from the Magnolia site to this stream location.

Based on the analytical results, barium and/or mercury were detected at elevated concentrations in the pore water samples; however, the levels were similar to the reference concentrations.

Sediments in the vicinity of both the Magnolia and Ajax Mine sites are being impacted by potential sources at the sites, though sediments near the Ajax Mine appear to be slightly less impacted than those near the Magnolia site. The sediment samples with the most exceedences of comparison criteria were those from the ponds and the overland route from the seep below the waste pile at the Ajax Mine.

AMD was observed flowing from the east adit at the Magnolia site and the adit at the Ajax Mine. Red-colored staining was also observed coming from the pond at Ajax, as well as downgradient from a seep at the base of the waste rock pile near the creek. All stream and pond samples had neutral pH levels.

Examination of the index scores revealed no impacts to the Lucas Gulch or Granite Creek benthic communities from either the Magnolia or Ajax Mines. Furthermore, the habitat does not appear to be impacting the benthic community.

The redband trout (*Oncorhynchus mykiss*) and possibly the cutthroat trout (*O. clarki*) were observed in the vicinity of the sites. Both species are federally listed as SOC and identified as vulnerable species by the Oregon Fish and Wildlife Commission.

3.3 SOIL EXPOSURE PATHWAY

3.3.1 Targets

There are no residents living on site or within 200 ft of areas of suspected contamination related to the sites. There is still an active claim at Magnolia Mine however, and at least one person works at the site on an occasional basis. The lower settling pond had recently been drained and backhoe tracks were observed. In addition, a small cabin at the site was being used for storage. According to the USFS EIS performed in 2002, these activities are being conducted with the knowledge and approval of the USFS.

The closest building, a small cabin, is located approximately 0.6 mi from the Magnolia site and 0.4 mi from the Ajax site, although it is unknown whether this cabin is occupied on a regular basis. With the

exception of this cabin, the closest buildings are homes on the fringes of Granite, approximately 2.5 mi from the sites. The town of Granite is located approximately 3 mi from the sites (straight-line 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.

The road to the sites is gated and locked, and access is generally not an issue. Land uses in the site area include recreation (hiking, fishing, camping, etc.), mining on nearby claims, and limited timber harvesting.

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 Lucas Gulch and reference/background stations.

To accomplish the 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 during 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 plant 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 the small riparian zone along Lucas Gulch. This strip ranges from 10-15 meters wide and is bounded on both sides by extremely steep slopes.

- Using the NVCS system, the hillsides were classified as “woodland,” because the cover was less than 60 percent (II.A.4.N.b.).

- Vegetation type differs on the steep slopes due to orientation, however the dominant plant types on both were douglas fir (*Pseudotsuga menziesii*), and lodgepole pine (*Pinus contorta*). The hillside forest is typical for the Blue Mountain ecosystem (Franklin and Dyrness 1973), with large numbers of dead snags and near absence of understory. The understory species present consisted of grasses, forbs, and whortleberry (*Vaccinium scoparium*). The condition of the forest on the hillsides indicated a history of logging, fire, and possibly insect infestation.

- The riparian zone has extensive sections of dead willows, perhaps indicative of recent fires, but is dominated by alder (*Alnus rubra*) and dogwood (*Cornus stolonifera*) with a major understory of grasses, sedges, and horsetails.

- Lucas Gulch ranges from 3 to 10 ft wide in the vicinity of the mines and was not more than 1 ft deep. In spots in was slow moving and sluggish.

Vegetation

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

- The steep slopes and hillsides on either side of Lucas Gulch
- The riparian zone along the valley floor.

Most of the surrounding hillsides are steep; the forest was in poor condition with over 25 percent dead snags in some places. Wild strawberry (*Fragaria virginiana*), the plant species selected for plant tissue collection (see below) was widespread in a variety of habitats.

Prior to conducting the fieldwork, a list of T&E plant species and SOC was generated, obtained from the Wallowa-Whitman National Forest (Appendix E, Table E-3). In addition, the ONHIC was contacted regarding any specific recorded observations of T&E plant species and SOC within a 2-mi radius of the sites (the search range available from the ONHIC). Two species of *Carex*, northern sedge (*Carex concinna*) and 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 Wallowa-Whitman list were observed during the SI. The plant species that were observed during the SI are listed on Table E-4 (Appendix E).

The understory vegetation along Lucas Gulch is generally nonvascular with the primary species being horsetails (*Equisetum* sp.) with forbs and fewer grasses. There are a few areas of scrub-shrub (mostly alder with some red-osier dogwood) occurring at the confluence with Granite Creek. The NVCS code for the riparian area would be a temporarily flooded cold-deciduous shrubland (III.B.2.N.d.).

Wildlife

Prior to conducting the fieldwork, a list of T&E wildlife species and SOC potentially occurring in Grant County was generated with data obtained from the OHNP (Appendix E, Table E-1). In addition, the ONHIC was contacted regarding any specific recorded observations of T&E wildlife species and SOC within a 2-mile radius of the sites (Appendix D). The search indicated that the spotted frog (*Rana luteiventris*), a federal and state sensitive species, has been documented within 2 mi of the sites.

The species observed in the vicinity of the Magnolia and Ajax Mine sites during the SI are listed in Table E-2. Very few wildlife species were observed at either site. Three species of mammals, and no reptiles or amphibians were observed. The mammal observations consisted of a vole (*Microtus* sp.), yellow pine chipmunk (*Eutamias amoenus*), and the scat of mule deer (*Odocoileus hemoionus*). No terrestrial T&E species or SOC were observed during the SI.

Birds and Waterfowl

All the bird species observed were associated with the hillside forests; no waterfowl were observed during the SI. The only species observed along Lucas Gulch was the american robin (*Turdus migratorius*). Observations of the other birds consisted mostly of hearing the calls from the surrounding forest, primarily mountain chickadee (*Poecile gambeli*), western tanager (*Piranga ludoviciana*), and golden-crowned Kinglet (*Regulus satrapa*).

3.3.3 Sample Locations

Background Locations

A total of 4 background surface soil samples were collected outside of the influence of the Magnolia and Ajax Mine sites. The samples were collected at approximately 0.5 ft below ground surface (bgs).

- Three samples were collected in the vicinity of the upper Granite Creek watershed during the Granite Creek SI (GRAN-34, 35, and 36; EA 2003d).

- One sample was collected near the Magnolia site (LUCA-19). The sample was located just inside the woods at the edge of the meadow, to the north of the collapsed cabin. This area of the site was presumed to be outside of the influence of mining activities.

3.3.3.1 Soil and Waste Samples

The locations of the soil and waste samples are described below.

Magnolia Mine

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

- One sample was collected from the lower settling pond (MAGN-12). The sample was collected from the red "sludge" material at approximately 0.3 ft bgs. Below the layer of red sludge there was a layer of grey material with gravel.

- One sample was collected in the vicinity of the former stamp mill (MAGN-15). The sample was collected from 0.5 ft bgs.

- One sample was from the waste pile near the ponds (MAGN-16) and Lucas Gulch. The sample was collected from approximately 0.5 ft bgs.

Three subsurface soil and/or waste samples were collected:

- One sample was collected from the waste pile located near the upper collapsed portal (MAGN-14). The sample was collected from the edge of the slope from approximately 2.5 to 3 ft bgs.

- One sample was collected approximately 10 ft downhill of the waste pile near the upper collapsed portal (MAGN-18). The sample was collected from approximately 1 to 1.5 ft bgs.

- One sample was collected at the waste pile located at the southern end of the site just upgradient of Lucas Gulch (MAGN-17). The sample was collected from approximately 1.5 to 2 ft bgs.

Ajax Mine

Three subsurface soil and/or waste samples were collected at the Ajax Mine site:

- One sample was collected from the waste rock pile located near the upper adit (AJAX-10). The sample was collected at approximately 2 ft bgs.

- One sample was collected from the waste rock pile located near the settling pond and adjacent to the creek (AJAX-09). The sample was located along a path of stained soil coming from the pond, possibly where water has overflowed from the pond.

- One sample was collected at the toe of the waste rock pile, along the runoff channel from the seep (AJAX-08).

3.3.3.2 Plant Tissue Samples

Plant tissue specimens were collected from 3 onsite stations at Magnolia Mine, 2 onsite stations at Ajax Mine, and 4 background stations. Three of the background stations were located on the hillsides within the Granite Creek drainage, but outside of the mining activity. One of the background stations was located within the Lucas Gulch drainage. 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 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.

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

- Three stations at the Magnolia Mine site (MAGN-11, 14 and 17)
- Two stations at the Ajax Mine site (AJAX-06 and 08)
- Four background areas (GRAN-34, 35 and 36 and LUCA-19).

3.3.4 Analytical Results

All soil and/or waste samples collected at the Magnolia and Ajax Mines were analyzed for pH, TAL metals, chromium VI, and cyanide. Synthetic Precipitation Leaching Procedure (SPLP) and Acid Base Accounting (ABA) parameters were also included as appropriate. 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.

The plant tissue samples were analyzed for cyanide and TAL Metals. 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 Rock Samples

A summary of the surface and subsurface soil/waste samples is provided in Table 4. Soil sample descriptions are provided in Appendix I. Surface and subsurface soil sample analytical results are summarized below.

Sample Type	Table/ Sample Nos.	Metals Exceeding One or More Comparison Criteria (in at least one sample)	Metals Notably Above Highest Background Concentration (in at least one sample)	Trends Observed and Comments
Soil/Waste Rock	**Table 4**			
Background				
Surface Soil	GRAN-34, GRAN-35, GRAN-36 and LUCA-19	Aluminum, arsenic, barium, beryllium, chromium, manganese, mercury, selenium, vanadium, and zinc.	NA	In general, some of the higher concentrations were detected in the soil sample collected near Lucas Gulch (Plate 2).
Magnolia Mine				
Surface Soil/Waste Rock:	MAGN-12, MAGN-15, and MAGN-16	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc	Antimony, arsenic, cadmium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc	Of the metals detected at concentrations above the comparison criteria in surface soil samples, aluminum, barium, beryllium, chromium and vanadium were comparable to the background concentrations. In general, the highest concentrations were detected in the sample collected from the lower settling pond (MAGN-12).
Subsurface Soil/Waste Rock:	MAGN-14, MAGN-17, and MAGN-18	Aluminum, antimony, arsenic, barium, beryllium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc	Arsenic, lead, mercury, nickel, selenium, silver, and thallium.	Of the metals detected at concentrations above the comparison criteria in surface soil samples, aluminum, barium, beryllium, and chromium were comparable to the background concentrations. In general, some of the highest concentrations were detected in the sample collected from the waste pile located near the upper collapsed portal (MAGN-14).

Sample Type	Table/ Sample Nos.	Metals Exceeding One or More Comparison Criteria (in at least one sample)	Metals Notably Above Highest Background Concentration (in at least one sample)	Trends Observed and Comments
Ajax Mine				
Subsurface Soil/Waste Rock:	AJAX-08, AJAX-09, and AJAX-10	Aluminum, antimony, arsenic, barium, beryllium, chromium, copper, manganese, mercury, selenium, thallium, vanadium, and zinc	Antimony, arsenic, and mercury	Of the metals detected at concentrations above the comparison criteria, aluminum, barium, beryllium, and chromium were comparable to the background concentrations.

NA – Not applicable.

Plant Tissue Samples

A summary of the plant tissue sample results is provided in Table 5. Currently, no comparison criteria are available for plant tissue. The analytical results are discussed in the following table:

Sample Type	Table/ Sample Nos.	Metals Exceeding Background Concentrations (in at least one sample)	Metals Notably Above Highest Background Concentration (in at least one sample)	Trends Observed and Comments
Plant Tissue	**Table 5**			
Background				
Plant Tissue	GRAN-34, GRAN-35, GRAN-36, and LUCA-19	NA	NA	Antimony, arsenic, cobalt, and mercury were not detected in any of the background samples.
Magnolia Mine				
Plant Tissue	MAGN-11, MAGN-14 and MAGN-17	Aluminum, arsenic, iron, lead, magnesium, selenium, and zinc were detected above the background sample concentrations.	Arsenic and iron.	With the exception of magnesium and iron, all of the metals detected above background in the plant tissue samples were also detected above the comparison criteria in the colocated soil samples at MAGN-14 and MAGN-17. Arsenic was detected in the co-located soil samples at concentrations notably above background.
Ajax Mine				
Plant Tissue	AJAX-06 and AJAX-08	Arsenic, iron, lead, magnesium, and selenium were detected above the background sample concentrations.	Arsenic and iron.	Arsenic and selenium were also detected above the comparison criteria in the colocated soil sample collected at AJAX-08, although selenium was not at a notably high concentration.

NA – Not applicable

3.3.5 Soil Exposure Pathway Summary

There is evidence of releases of site-related contaminants to soil at the Magnolia and Ajax Mine sites. A number of metals were detected in onsite surface soil and waste rock pile samples at concentrations exceeding comparison criteria. Although 10 metals were detected at concentrations above the comparison criteria in the background surface soil samples, a number of metals were detected in surface and/or subsurface samples at both sites at concentrations exceeding the comparison criteria and at elevated concentrations compared to background:

- Antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, selenium, silver, thallium, vanadium, and zinc at the Magnolia Mine site. Overall, it appears that the highest concentrations of metals were detected in the samples collected from the lower pond (MAGN-12), the waste pile near the upper eastern collapsed adit (MAGN-14), and the mill site (MAGN-15). Most notably, arsenic, mercury, nickel, and zinc were detected at very high concentrations in the surface soil sample collected in the lower pond (MAGN-12).

- Antimony, arsenic, and mercury at the Ajax Mine site. No specific trends were noted.

Plant tissue samples also contained concentrations of metals that exceeded both the comparison criteria and background concentrations. At both mine sites, only arsenic was detected in both the plant tissue and the co-located soil samples at concentrations above the comparison criteria.

Erosion of fine-grained waste material was evident at both mine sites adjacent to the waste piles along Lucas Gulch. These eroded waste materials would enter the creek during periods of high rainfall and snowmelt.

No listed terrestrial T&E species or SOC were observed within the project area at either site during the SI.

3.4 AIR PATHWAY

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 0.6 mi from the Magnolia Mine and 0.4 mi from the Ajax Mine, although it is unknown whether this cabin is occupied on a regular basis and may be related to local mining operations. It is estimated that there is 1 residence within 1 mi of the Magnolia and Ajax 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. The North Fork John Day Wilderness Area, considered a sensitive environment, is located within a 4-mi radius of the sites.

3.4.2 Air Pathway Summary

- Air samples were not collected as part of this SI. The most likely air pathway at the mine sites is through inhalation of particulate matter. The air pathway is considered complete for the Magnolia site, as arsenic was detected in 2 shallow soil samples at concentrations exceeding the USEPA soil screening level for inhalation of particulates. 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, if the soil pathway is addressed.

4. SUMMARY AND CONCLUSIONS

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

Groundwater Pathway

- The use of groundwater for drinking water within the target area is limited to 1 well, located between 3-4 mi from the sites. Considering the depth of the well and the distance from the sites, it is very unlikely that this well could be impacted from groundwater coming from the sites. 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. Therefore, the groundwater pathway appears to be incomplete.

Surface Water Pathway

- A number of metals were detected at concentrations above the comparison criteria in the water samples collected at the east adit and the upper retention pond at the Magnolia Mine. A number of metals were also detected at elevated concentrations in the sample collected from the adit at Ajax Mine.

- There is evidence of an ongoing release of arsenic from sources at the Magnolia Mine to surface water in Lucas Gulch. Based on the results, arsenic is migrating downstream from the Magnolia site to the onsite stream station at Ajax Mine. The results suggest that there is not an ongoing release of metals from potential sources to surface water at the Ajax Mine.

- Based on the analytical results, metals from the mine sites are not impacting the pore water in the project area.

- The analytical results indicate that contaminants from the sites are not impacting surface water in Granite Creek.

- Sediments in the vicinity of both the Magnolia and Ajax Mine sites are being impacted by potential sources at the sites. The stream sediment samples collected at the Magnolia site had higher concentrations of metals in comparison to the Ajax site. The sediment samples with concentrations that had the most exceedences of comparison criteria were those from the ponds and the overland route from the seep below the waste pile at the Ajax Mine.

- The redband trout (*Oncorhynchus mykiss*) and possibly the cutthroat trout (*O. clarki*) were observed in Lucas Gulch in the vicinity of the sites. Both species are federally listed as SOC and identified as vulnerable species by the Oregon Fish and Wildlife Commission. It is possible that these species are being impacted by the mines, however, this has not been determined.

Soil Exposure Pathway

- A number of metals were detected in surface and/or subsurface soil samples at concentrations exceeding comparison criteria at both mine sites. Overall, the highest concentrations of metals in soil and waste samples at the Magnolia Mine were detected in the samples collected from the

lower pond, the waste pile by the upper east collapsed adit (MAGN-14), and the mill site. No notable patterns were observed at the Ajax Mine site.

- At both mine sites, arsenic was detected in both the plant tissue and the co-located soil samples at concentrations above the comparison criteria.

- Both sites include waste rock piles and contaminated soil from AMD. Erosion of fine-grained waste material was evident at both mine sites adjacent to the waste piles along Lucas Gulch. These eroded waste materials would enter the creek during periods of high rainfall and snowmelt.

- There is a potential for future overflows of the retention ponds at both sites. Such an event would allow the discharge of AMD, sediment and flocculent to enter Lucas Gulch.

Air Pathway

- The air pathway is considered complete for the Magnolia site, as arsenic was detected in 2 shallow soil samples at concentrations exceeding the USEPA soil screening level for inhalation of particulates. 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, if the soil pathway is addressed.

Recommendations

Based on the information presented herein, EA recommends performance of an Engineering Evaluation/Cost Analysis (EE/CA) at both the Magnolia Mine and Ajax Mine. As part of the EE/CA, a risk assessment should be performed to assess the human and ecological impacts, establish site removal cleanup standards, and evaluate remediation technologies.

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Figures

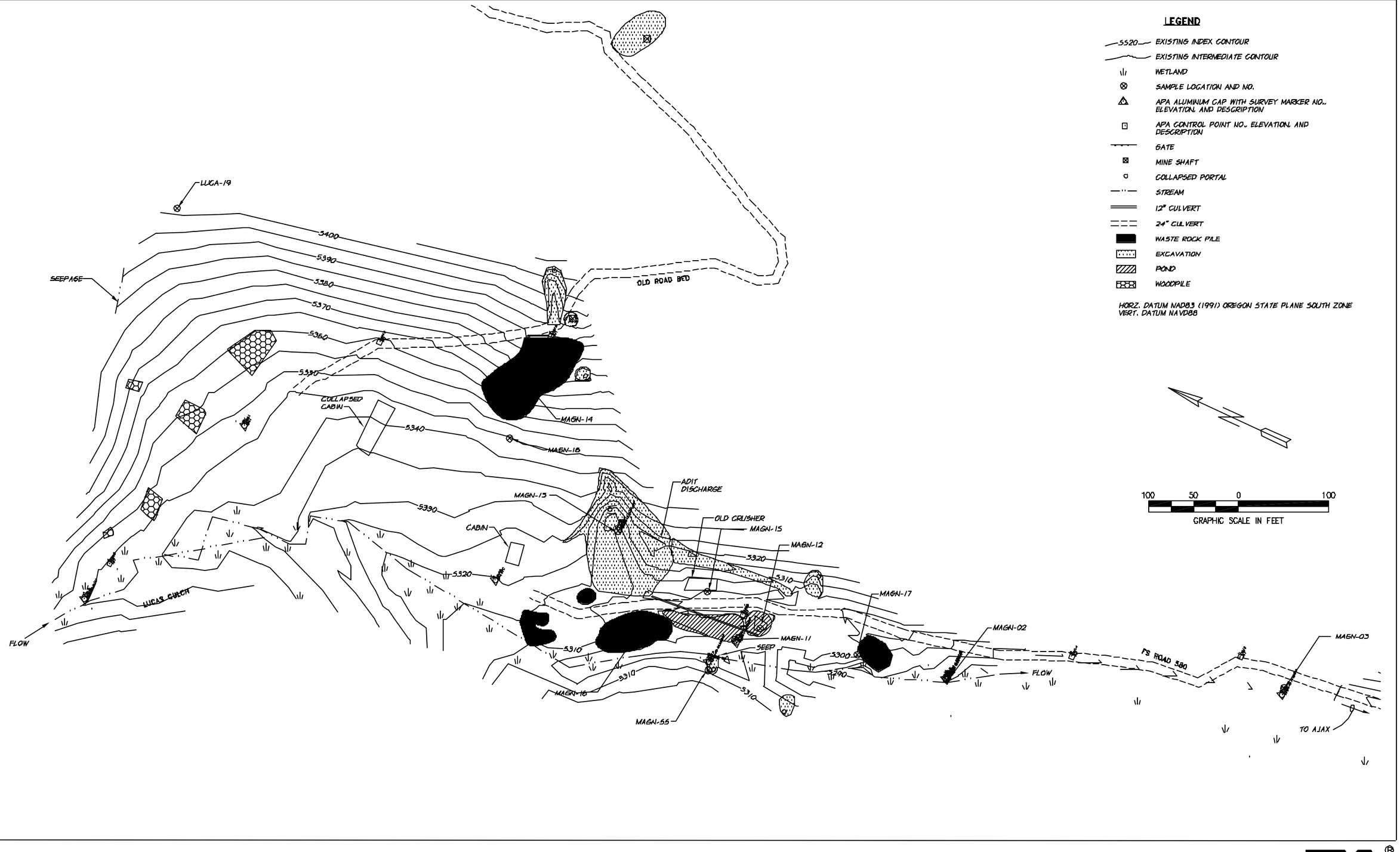

Figure 1. MAGNOLIA MINE SITE

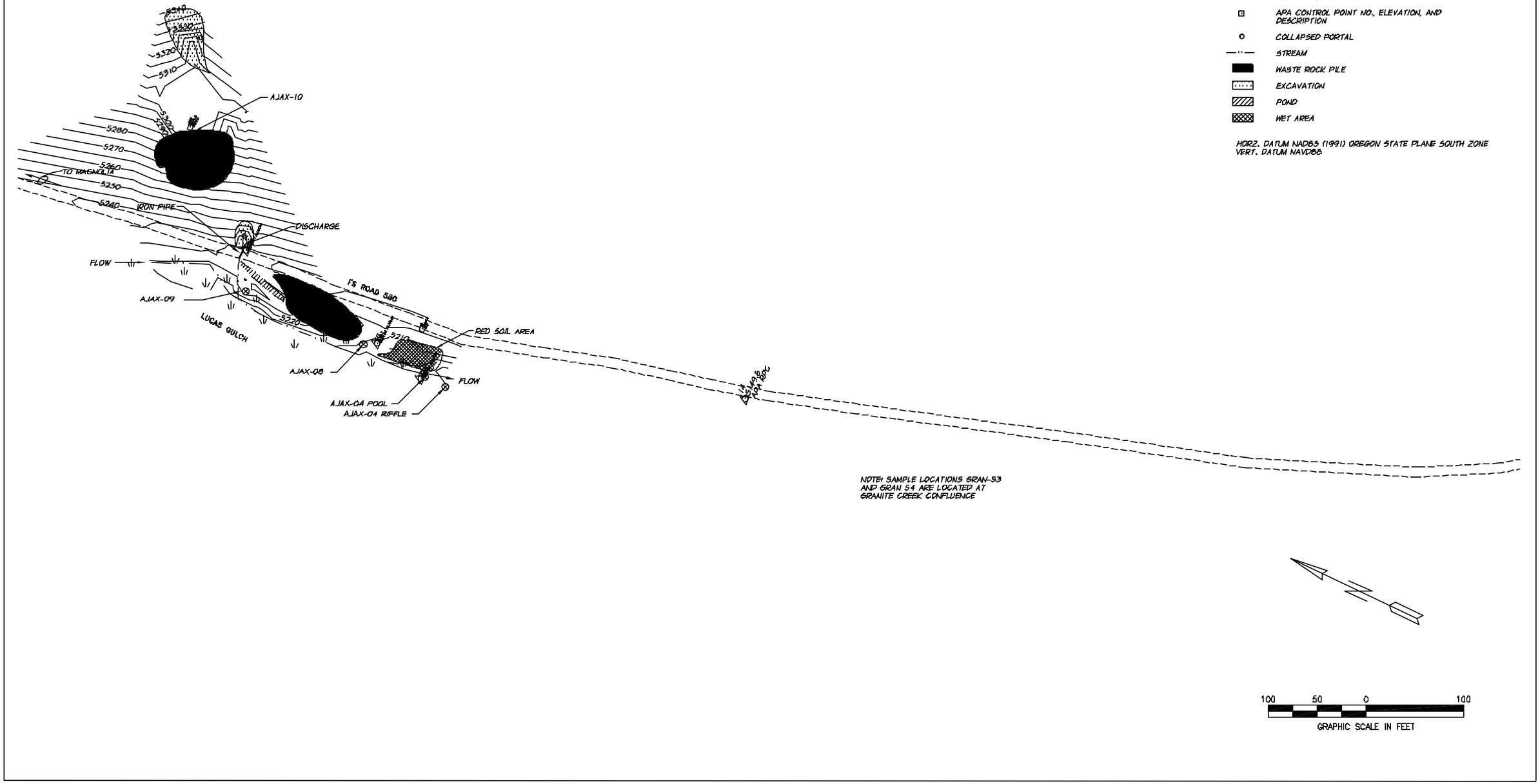

Figure 2. AJAX MINE SITE